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TECHNICAL REPORT TO THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HEALTH APPLICATIONS OFFICE
HOUSTON, TEXAS

APPLICATION OF SELECTED METHODS OF REMOTE SENSING FOR DETECTING CARBONACEOUS WATER POLLUTION

CONTRACT NAS 9-12[illegible]

THE UNIVERSITY OF TEXAS AT HOUSTON
SCHOOL OF PUBLIC HEALTH
INSTITUTE OF ENVIRONMENTAL HEALTH

DECEMBER, 1972

Report To

National Aeronautics and Space Administration

Manned Spacecraft Center

Health Applications Office

Houston, Texas

APPLICATION OF SELECTED METHODS OF REMOTE SENSING FOR DETECTING CARBONACEOUS WATER POLLUTION

Contract NAS 9-12040

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INTRODUCTION

Remote sensing, or to be more specific to the purpose of the investigation which is reported herein, aerial remote sensing, is a tool which has been used since some point in time at which man first carried a camera aloft and exposed photographic film to record an image of what lay beneath him. The concept therefore of recording temporal and spatial data of a part of earth's surface on film or by some other means of record is not necessarily a new one. What has developed as a new concept in recent time is the realization that more of our surface waters are being contaminated by the addition of pollutants and as the result of such additions they are, in fact, being measurably polluted. Additionally, and of at least equal importance, is the obvious need for remote sensing methods which may be applicable to the rapid assessment of the amount of pollution present in a surface water ecosystem at any point in time. To accomplish this goal the approach which must be undertaken is one of correlation of imagery data with data developed from surface sampling investigations. The

latter have been termed "ground truth" data collection.

The purposes for this project were two-fold. The question of whether organic pollutants or other commonly measured water quality parameters could be quantitatively assessed from aerial remote sensing imagery had to be answered. And, the limits of application of data correlations were to be identified.

Previous investigations have approached this problem from different viewpoints. A complete assessment of the feasibility of water pollution by aerial remote sensing was presented earlier by Davis[10]. All attempts have been cognizant of the peculiar characteristics of the medium in which the research efforts have been conducted. Many of the spectral properties of water preclude research attempts in certain wavebands. As White[1,2] has so clearly pointed out, if light penetration is the required objective, the only spectral region which has some use is that between 0.38μ and 0.7μ. This, of course, is the visible region. And within this band, the capacity of water to allow penetration is near 0.5μ. Polcyn, et al[3,8] quoted the narrow region of 0.52μ to 0.58μ for penetrability efficiency. This restriction was also cited

in a comprehensive treatise on pollution measurement capability published by NASA[4]. Radiation emission from the water surface occurs in three spectral bands. They are from, approximately, 0.35μ-2.5μ, 3.3μ-5.0μ, and 8.0μ-14μ. In the near ultraviolet region below 0.38μ, interference occurs due to the high molecular scattering property of water. Above 0.7μ, and through the infrared region (past 20.0μ), water has exceptionally high absorptive properties. Then too, the atmosphere itself possesses the capacity to absorb or scatter electromagnetic energy even in the absence of cloud cover or man-made contributions to the atmosphere. Scattering occurs in the region below 0.35μ and atmospheric absorption occurs between 2.6μ-3.3μ, 5.0μ-8.0μ, and above 15.0μ. The limit to which some of the imagery developed by conventional methods can be put to use becomes immediately apparent.

Recent investigations have attempted to demonstrate secondary correlations; ie., post-cause and effect relationships. A principal consideration has been that of penetrability and the related concentration of chlorophyll. Arvesen[5] reported his attempts to correlate differential radiometer measurements of chlorophyll in the range of

0.02 mg/M^3 to greater than 10 mg/M^3. Duntley[6], in considering possible application of detecting chlorophyll in ocean waters from, presumably, earth satellites, essentially rediscovered the spectral absorbance of chlorophyll in the visible spectrum. Atwell[7], approached the subject of correlation of water content and film density from a most realistic direction. He demonstrated some correlation between imagery developed from KA62 instrumentation using a ratio of blue/green; red wavelength reflectance versus the concentration of chlorophyll *per se*. This systematic approach apparently offered some promise at quantification, however, as the author pointed out, turbidity, reflectance off the bottom in shallow water, and high concentrations of chlorophyll, which normally yield added reflectance as well as absorption, all constitute interferences in the method.

Some of the obvious mathematical relationships of, for example, water reflectance, have been expanded to apply to individual circumstances. The contrast between polluted water and non-polluted water can be measured in terms of a fractional difference. This relationship has been published[4] and in equation form is represented by

$C = (R_p - R)/R$, where R is the directional spectral reflectance of non-polluted water, R_p represents the directional reflectance of polluted water adjacent at the first area represented by R, and C equates to the inherent spectral contrast of the polluted water. Additionally,the indication was presented that atmospheric interference resulted in variances in the value of "C". An apparent spectral contrast, C', apparently always appears as a lower value than the inherent spectral contrast, "C", due to this interference. The ratio of C'/C, the contrast transmittance, for cloudless days was presented[4] for three wavelengths. The following table presents those data:

	Contrast Transmittance (C'/C)		
Wavelength, mμ	Highest Value Obtained	Average of 200 Days	Lowest Value Obtained
650	0.90	0.70	0.50
550	0.50	0.35	0.20
450	0.35	0.20	0.05

The data were all taken during a solar altitude of between forty and fifty degrees to horizon. In a more recent report, Mueller[9], developed mathematical relationships between Secchi depth values (penetration) and chlorophyll concentration by interrelating principal components of

ocean water spectra. Data were also developed for clear and slightly turbid ocean waters. The reason, as pointed out earlier, that these latter two considerations must be met is due to the light scattering ability of turbidity particles. The relationship between chlorophyll concentration, C, and ocean water color components, Y_1 and Y_2, was found to be

$$\ln (0.508 + C) = 1.0085 - 0.5149\ Y_1 + 1.2790\ Y_2$$

and that between Secchi depth and the two components in turbid and clear ocean water samples, respectively, were found to be

$$Z_{s(p)} = 5.483 + 1.768\ Y_1 \quad \text{and,}$$

$$Z_{s(p)} = 9.214 - 7.833\ Y_2$$

The approaches taken by these investigators have resulted in meaningful interpretations of some of the problems which confront any research effort.

A similar approach was taken for this investigation but with a different set of parameters. One of the principal components of most pollution sources is organic carbon. Measured by the biochemical oxygen demand (B.O.D.), chemical oxygen demand (C.O.D.), or total organic carbon (T.O.C.) analyses, this factor represents one component of pollution volumes which must be correlated with aerial

remote sensing imagery before final attempts at water resource management or pollution abatement practices can proceed further.

METHODOLOGY

Ground truth data were developed from field sampling and analysis of the waters in a region of the Houston Ship Channel near Morgan Point and Barbour's Cut. Four field survey and sampling trips were conducted and were scheduled to correspond in time to overflights by the NASA, NP3A aircraft. The flights were those being conducted in conjunction with a cooperative study of Trinity Bay, an integral part of the Galveston Bay estuarine complex. These sites are located in Houston Area Testsite 175. Details of the purpose and intent of the Trinity Bay investigation have been described by Zaitzeff and Whitehead[11]. For purposes of continuity, the field sampling area chosen for this investigation constituted the westernmost limit of Flight Line #3 of the Trinity Bay study.

Tests conducted in the field were those for the following physical and chemical factors: pH, dissolved oxygen, temperature, and Secchi Disc (light penetration). Routine tests were conducted on samples returned to the laboratory: turbidity, specific conductance, Salinity,

total inorganic carbon, total organic carbon, biochemical oxygen demand, chemical oxygen demand, and chlorophyll. The test for chlorophyll was conducted according to the procedure outlined by Strickland and Parsons[12]. The remaining tests were conducted in strict accordance with the procedures set forth in Standard Methods[13].

Pursuant to one of the purposes of the overall investigation, namely, the quantification and correlation of carbon content in the waters, more sophisticated analytical techniques were employed than usual in evaluating pollution parameters. Infrared spectrophotometric analyses of three different types were run on each water sample which was returned to the laboratory. The analyses included aqueous reflectance spectroscopy, carbon tetrachloride extraction procedures, and sample concentration on potassium bromide crystals. The Beckman Instruments IR-20 Spectrophotometer was used for all infrared analyses.

A fairly new concept in infrared spectral analysis is that of using aqueous samples for reflectance analysis. The unit which is used for this analysis is the Beckman ATR(TR-9L), KRS-5. Some of its characteristics are unlike

any usually found in hardware associated with infrared spectrometers. The crystal is a paired unit constructed of thallium bromide-iodide (KRS-5) having a response range of 0.5-40 microns. The unit containing the crystal (TR-9L) is a multiple reflection ATR unit. Nine reflections are achieved with the standard crystal: each reflection having an angle of incidence of 45°. The crystal remains in a fixed position relative to the optical path regardless of the sample thickness. The crystal is designed in a trapezoidal geometric configuration and is held in place by the stainless steel holder with aluminum faced gaskets. Problems were encountered with the KRS-5 crystal. When using highly saline water, a rust colored film developed on the crystal surface during use. The mechanism, compound or compounds formed, and reasons for said deposition are, as yet, unknown. The deposition was found to have been totally resistant to organic and inorganic solvent dissolution. Repolishing with pure silk was shown to temporarily alleviate the problem although the procedure had to be repeated after each scan. For absorption infrared spectroscopic analysis, the following procedure was adhered to in all cases. Carbon tetrachloride, spec.-grade, was added to individual samples in

a ratio of 10% in a separatory funnel and rocked for 15 minutes. Interfacial films which developed were discarded as their incorporation in the samples caused transmissivity interference. Cells utilized for double-beam operation included the following units:

1. F-05, RIIC, 0.1 mm pathlength with KBr windows (sample cell);
2. XL-0, RIIC, set equivalent to 0.1 mm path-length, KBr windows, variable pathlength cell (reference cell).

Reproductions of reference curves for all of the spectral data to be presented in following chapters are presented in Figures 1 and 2. The broad absorption band shown in Figure 1 constitutes the water peak.

Trinity Bay overflights which were correlated with ground truth activities pertinent to this investigation were the following:

Date	Mission	Site
October 7, 1971	186	256
February 4, 1972	192	256
June 8, 1972	204	256

Ground truth data was obtained on January 19, 1972, however, the overflight was cancelled due to excessive cloud cover after the boat was on station.

Some of the hardware which was in use during one or more of the overflights included the following units. Some of the pertinent data associated with each system on board accompany the hardware data.

I. Chicago Aerial KA62 Camera System:

Camera	Film	Filter	Resultant Band Pass (μm)
1	Plus X	VG28	0.38-0.52
2	Plus X	VG6	0.43-0.62
3	Plus X	OG590	0.55-0.72
4	B&W IR	RG695	0.68-0.90

Camera 4, used with a WR89B filter has a bandpass bordering 750 μm.

II. Wild Heerbrugg RC-8 Metric Camera System:

Camera	Film	Filter	Resultant Wavelength (μm)
1	Aerial Color	HF3	0.42-0.70
2	Ektachrome IR	WR15	0.52-0.90

III. RS-14 Dual Channel Infrared Scanner:

Option	Resultant Bandpass Channel 1 (70 mm film)	Channel 2 (mag. tape)
1	3.0-5.5 μ	8-14 μ
2	0.3-0.55μ	8-14 μ
3	1.0-1.3 μ	8-14 μ
	1.5-1.8 μ	
	2.0-2.5 μ	
	1.0-2.5 μ	
4	0.7-0.9 μ	8-14 μ

Imagery developed from the RS-14, IR Scanner, were that of Option 1, Channels 1 and 2.

Upon receipt, black-and-white imagery (5" x 5" frames) were subjected to interpretation by hardware located at NASA, MSC, Houston. These instruments constituted the following systems:

1. Tech/Ops. Model 608 Isodensitracer
2. International Sensing Systems (I^2S) Multiband Camera Film Viewer, Model 2000
3. Spatial Data Systems Datacolor Machine, VC-20 Series.

Imagery which was analyzed by personnel at NASA, MSC, Houston originated from the following missions. These data are presented in following chapters.

Imagery Analyzed By	Mission And Date 10/7/71	2/4/72	6/8/72
Isodensitracer	RS-14	KA62 B&W	---
I^2S	---	---	KA62 B&W
Datacolor	RS-14	KA62 B&W	---

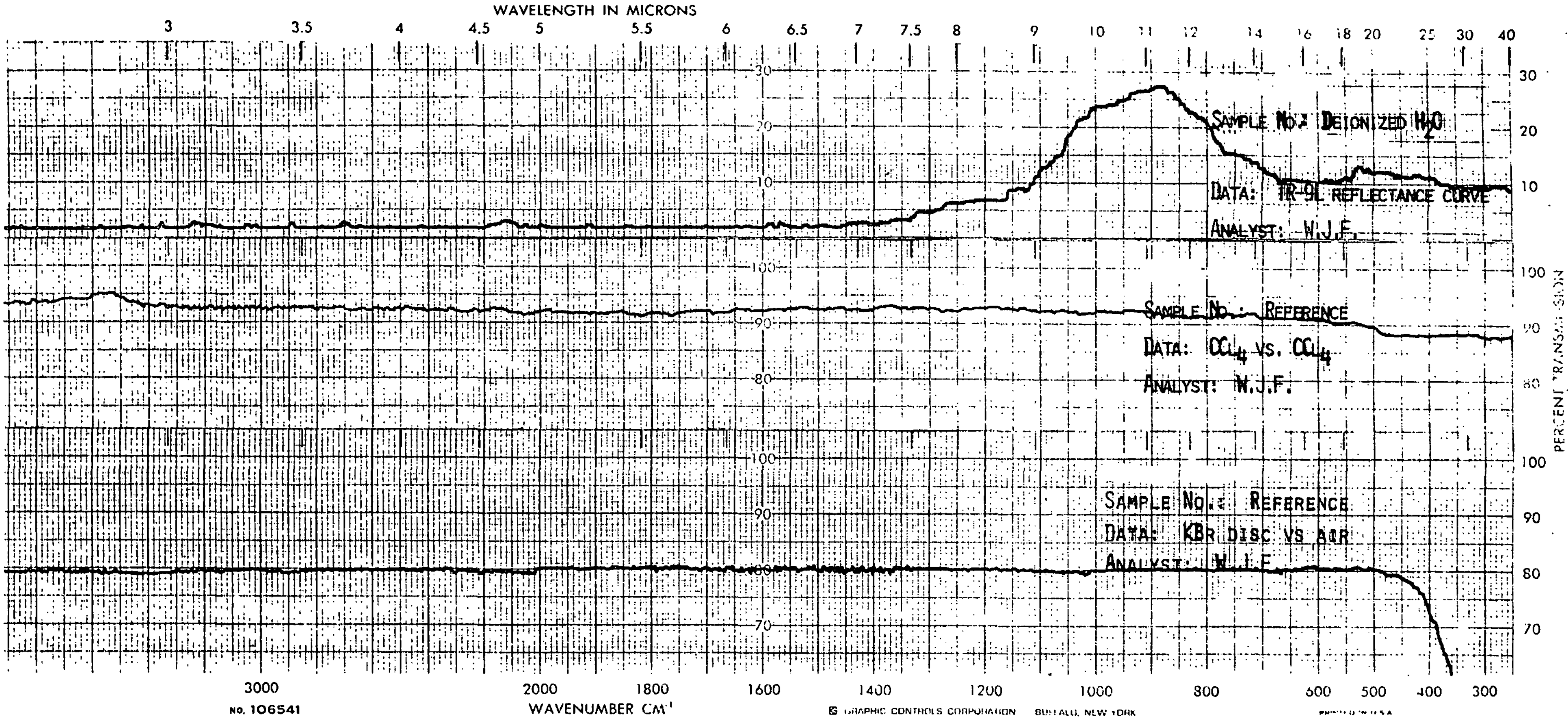


Figure 1. Control Curves For IR-20 Spectrophotometric Analyses: Reflectance, CCl_4 Blank, and KBr.

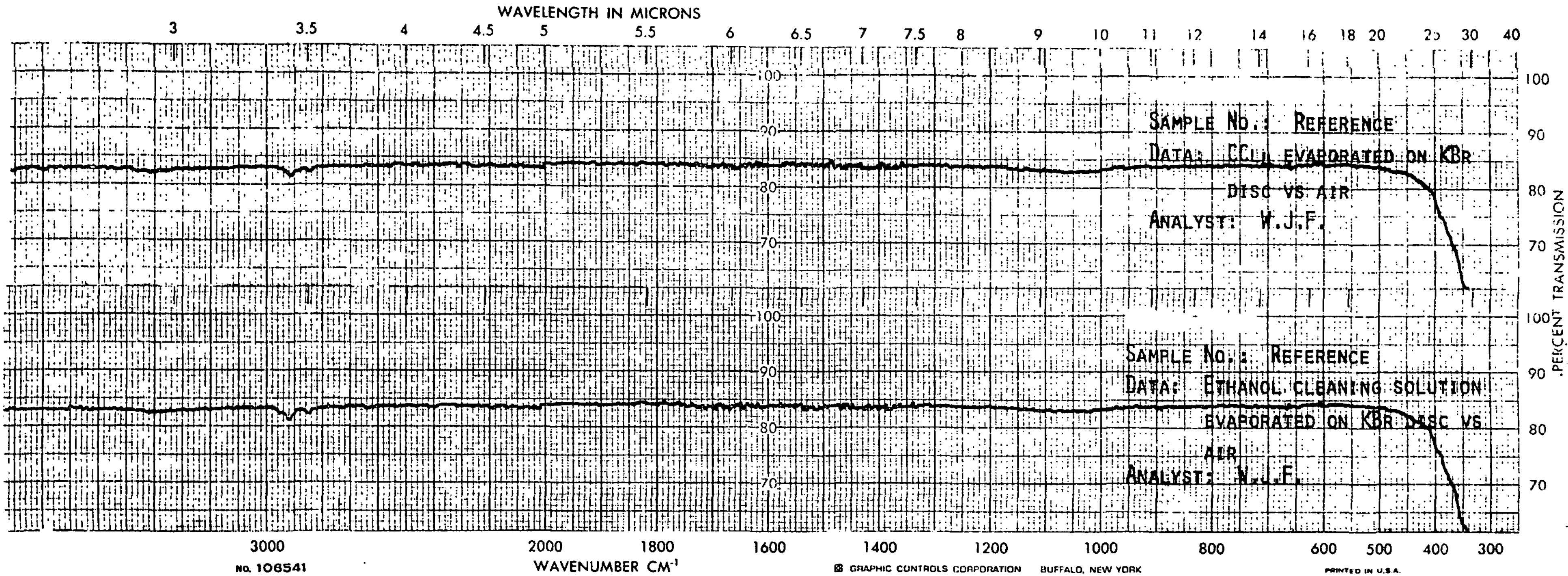


Figure 2. Reference Curves For IR-20 Spectrophotometric Analyses: Spec. Grade CCl_4 on KBr Disc, Spec. Grade E + OH Cleaning Solution.

RESULTS

Four field surveys were conducted in the test site area during the course of this investigation. Three of the surveys were conducted in conjunction with overflights and ground truth measurements occurring simultaneously. The fourth, January 19, 1972, resulted in cancellation of the flight due to a sudden increase in cloud cover in the area to the extent which precluded any meaningful photographic operation. Physical, chemical and biological data taken from ground truth measurements and samples taken on January 19, 1972 are included for record and may be used for comparison of the water quality of the area in question at future points in time. These data constitute appendix A, this report. Table 1 summarizes the data obtained from all techniques and hardware for the entire investigation.

October 7, 1971 Survey

A scale map of the test area at the mouth of the Houston Ship Channel and Galveston Bay and Barbour's Cut is presented on Figure 3. Physical and chemical data developed from samples taken at the eight locations shown in Figure 3 are presented in Table 2. These data represent

a water which had comparatively low specific conductance and salinity and give the appearance of being non-polluted due to the low C.O.D., B.O.D., and T.O.C. values. By all reports, this area should exhibit gross pollution, however, dilution effects from tidal activity and interference by toxicity due to such substances as heavy metals could have easily reduced the anticipated pollution levels of, say, the B.O.D. results. Note that relatively low concentrations of dissolved oxygen were present in the waters at the time of the survey.

Color imagery of the area is presented in Figure 4. Barbour's Cut is represented in the Figure in the upper center, the Houston Ship Channel to the upper right, and Galveston Bay to the lower left. The same geographical presentation is shown in Figure 5 which represents the area as depicted by color-IR imagery. At the time of the survey, Barbour's Cut was being dredged for deep draft vessels. The dredge and spoil line can be seen in Figures 4 and 5 near stations BC1, BC2, and BC3 and the resulting dredged spoil area is easily seen in the upper right quadrant of each reproduction. Turbidity imparted to the waters in Barbour's Cut and adjacent to Spilmans Island by the dredging operation should not be confused with the depth variations represented by the Channel and banks proper near Morgan Point,

Hog Island, and Atkinson Island. The imagery presents this physical phenomenon in that context nevertheless, which dictates additional interpretation effort and enhances the justification for ground truth data acquisition.

Figure 6 presents an Isodensitracer Recording of the Channel taken from an image recorded by Channel #2 (8-14u) of the RS-14 hardware. In this Figure Atkinson Island is the predominant image: Galveston Bay appears to the lower right. An interpretation of the color-coded density tracings is shown in Table 3. The maximum digit shown of 59 represents the maximum possible number of codes which could have been used in the machine interpretation of film density, had the RS-14 film, for example, contained that number of densities. The image in Figure 6 does not complete the Barbour's Cut area due to the end of that particular frame existing at the lower region of the photograph. A distinct density differential can be seen at the entrance to Barbour's Cut, located at the lower left of Figure 6.

Organic extraction and infrared Spectrophotometric analyses were applied to the samples taken during this survey.

TABLE 1

Summary Of Data

Field Survey:	October 7, 1971, Mission 186, Site 256, Flight 12.
Laboratory:	Physical, Chemical; 8 Stations Infrared Spectrophotometric Analysis 1. Reflectance ATR 2. CCl_4 Extract 3. KBr, Sample Residue
Imagery:	Color (RC-8 #1) Color IR (RC-8 #2) Isodensitracer Recording (RS-14, Option #1, Channel #2)
Field Survey:	January 19, 1972
Laboratory:	Physical, Chemical, and Biological; 22 Stations
Field Survey:	February 4, 1972, Mission 192, Site 256, Flight 5.
Laboratory:	Physical, Chemical, and Biological; 15 Stations. Infrared Spectrophotometric Analysis 1. Reflectance ATR 2. CCl_4 Extract 3. KBr, Sample Residue 4. Regression Analysis
Imagery:	Datacolor VC-20 (of KA62) Isodensitracer Recording (KA62)
Field Survey:	June 8, 1972, Mission 204, Site 256
Laboratory:	Physical, Chemical, and Biological; 15 Stations Infrared Spectrophotometric Analysis 1. Reflectance ATR 2. CCl_4 Extract 3. KBr, Sample Residue 4. Regression Analysis
Imagery:	I^2S Analysis (KA62, Camera 1, 2, and 3)

Figure 3

Sample Sites; Mission 186; Site 256; 10-7-71

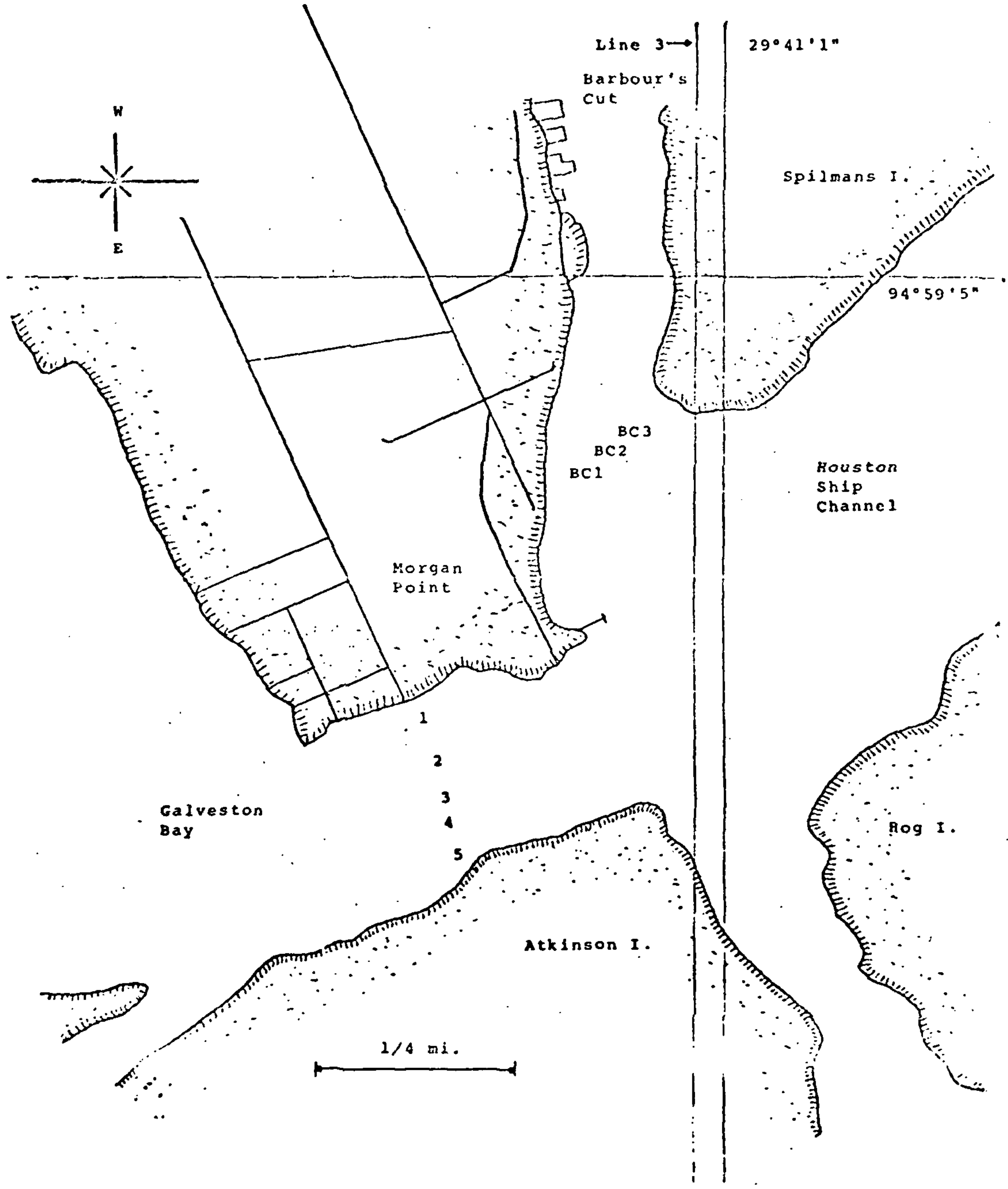


TABLE 2

Physical-Chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut During Mission 186, Test Site 256. Sampling Date, October 7, 1971.

Parameter	Station							
	1	2	3	4	5	BC1	BC2	BC3
pH	7.7	7.6	7.7	7.6	7.6	7.8	7.8	7.8
Dissolved Oxygen, mg/l	3.4	3.6	3.5	3.7	3.8	3.4	2.9	3.4
Dissolved Oxygen, % Saturation	46	49	47	50	52	47	40	47
Temperature, °C;								
Surface	26.0	26.0	26.0	26.0	26.5	27.0	27.0	27.0
40'	--	--	27.0	--	--	--	--	--
Secchi Disc, ft.	1.4	1.5	1.5	1.5	1.5	1.4	1.3	1.3
Turbidity, J.T.U.	37	43	45	41	42	30	36	50
Specific Conductance, μmhos/cm x 10^4	2.03	2.27	2.24	2.19	2.32	2.14	2.16	2.10
Salinity, °/₀₀	17	17	17	17	17	15	15	15
Total Inorganic Carbon, mg/l	19	19	21	23	22	22	22	23
Total Organic Carbon, mg/l	21	21	20	20	22	20	19	21
Chemical Oxygen Demand, mg/l	156	149	127	155	180	120	129	153
Biochemical Oxygen Demand, mg/l	3	3	< 4	< 4	< 4	< 4	< 4	5

FIGURE 4

CAMERA: RC8 #1

PRINT OF AERIAL COLOR FILM

DATE: OCTOBER 7, 1971

MISSION 186, SITE 256, FLIGHT 12

TIME: 0737

ROLL: 46

FILM TYPE: SO-397

W/O 3659

FRAME 3454

FIGURE 5

EKTACHROME IR PRINT

DATE: OCTOBER 7, 1971

MISSION 186, SITE 256, FLIGHT 12

TIME: 0737

CAMERA: RC8 #2

ROLL: 47

FILM TYPE: 2443

W/O 3659

FRAME 7092

TABLE 3

Isodensitracer Tracing Scheme
(0-1.6 Relative Density Differentials)

Machine Code*	Color	Print Notation
1-4	black	..
6-9	black	—
11-14	black	.
16-19	red	..
21-24	red	—
26-29	red	.
31-34	green	..
36-39	green	—
41-44	green	.
46	black	——
47-49	blue	..
51-54	blue	—
56-59	blue	.

* Increments of 0.133 each except Code 46 and 47-49 which are 0.044 and 0.089 respectively

FIGURE 6

ISODENSITRACING RECORDING

NASA S-72-50492

DATE: OCTOBER 7, 1972

MISSION 186, SITE 256

IMAGER: RS-14, OPTION 1,
CHANNEL 2

Isodensitracer Recording
Imager: RS-14 (8-14μ)
Magnification: 5X
Sample Location: Houston Ship Channel
and Barbour's Cut
Sample Date: 10-7-71

The IR Scans are all included in Appendix B. A summary of the absorption band data of interest in this investigation are presented in Table 4. The conclusions which can be drawn from these data are the following. The IR range of analysis (<3.0μ - >25μ) was outside limits of the RC-8 imagery. Correlation interpretation obviously is unrealistic for those images (Figures 4, 5). The 3.4μ band, however, did show excellent response to organic compounds (groups) present in the waters at the time of the survey. Note that the area in Barbour's Cut generally exhibited higher absorption peaks than the open Channel waters at that bandwidth. This phenomenon will be further examined in the following series of surveillance data.

February 4, 1972 Survey

Figure 7 contains the sample locations for the fifteen samples taken in the test site during this survey. Physical, chemical, and biological data developed from the samples are presented in Table 5. These data show that the waters at Station BC6 and #15, near the shore at Spilmans Island and Morgan Point, respectively, exhibited the only variances from remarkably similar water quality, for most parameters, throughout the test site. Near saturation, or supersaturation values for dissolved oxygen concentrations were found at all stations.

Table 4. Absorption Values For Three IR Spectrophotometric Analysis Techniques; October 7, 1971 Survey.

Station	Reflectance ATR $\sim 5.3\mu$	CCl_4 Extract $\sim 3.4\mu$	KBr Evaporate ~ 3.4	~ 8.5	~ 13
BC1	5	55	62	7	<1
BC2	7	62	59	3	2
BC3	<1	68	59	3	<1
1	2	61	46	0	45
2	9	44	38	0	10
3	8	34	33	0	0
4	5	47	43	**	26
5	3	30	*	*	*

* No data available

** Peak masked

Figure 7

Sample Sites; Mission 192; Site 256; 2-4-72

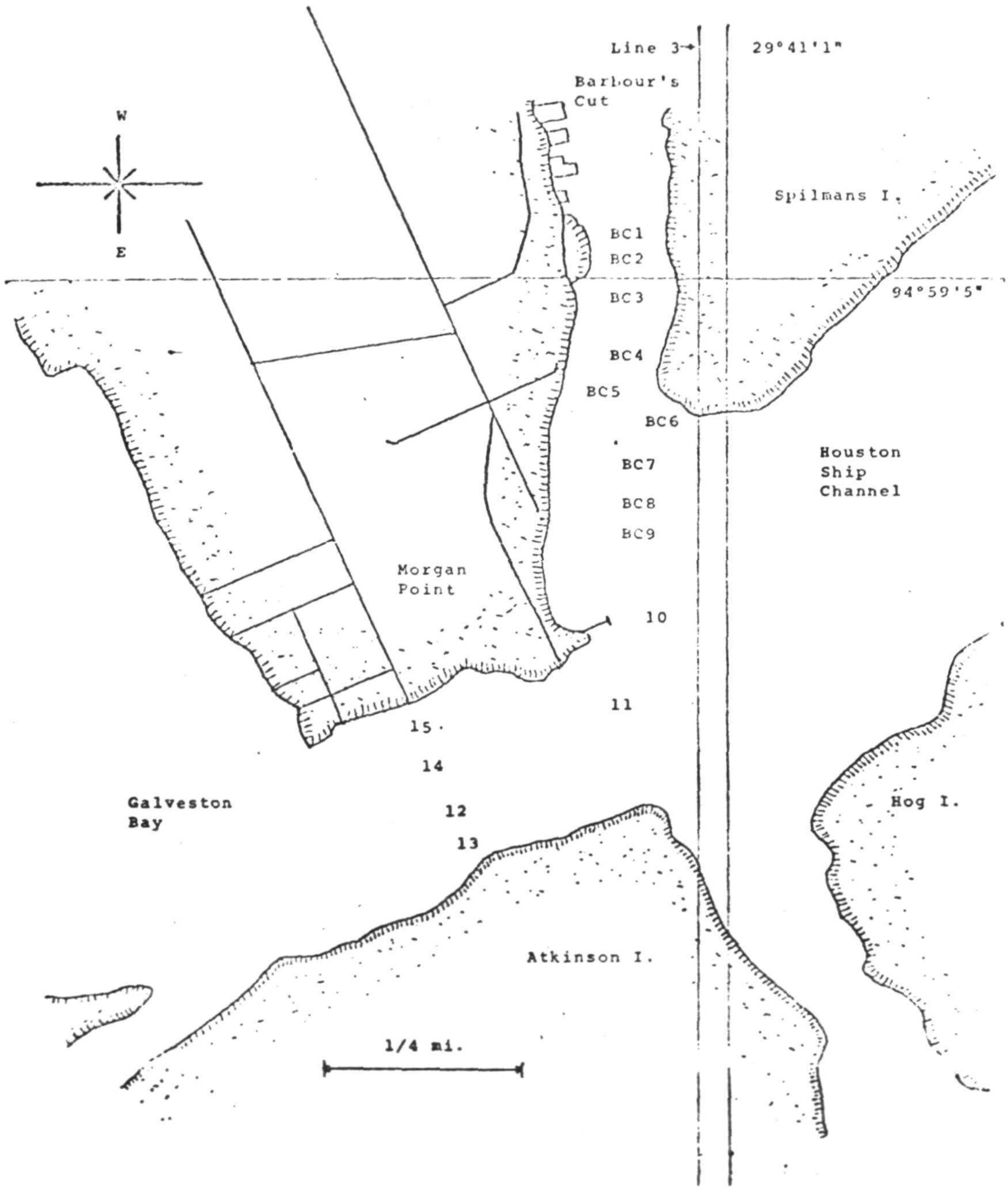


TABLE 5

Physical-chemical Data for Samples Taken From Houston Ship Channel and Barbour's Cut During Mission 192, Test Site 256. Sampling Date, February 4, 1972.

Parameter	Station						
	BC1	BC2	BC3	BC4	BC5	BC6	BC7
pH	8.0	8.1	8.0	8.1	8.1	8.05	8.05
Dissolved Oxygen, mg/l	9.8	9.8	9.2	9.9	10.1	9.9	10.2
Dissolved Oxygen % Saturation	99	97	92	99	101	99	102
Temperature, °C;							
Surface	11	10.3	10.5	10.5	10.5	10.5	10.5
Secchi Disc, in.	15	15	15	15	14	12	14
Turbidity J.T.U.	33	35	31	35	47	132	47
Specific Conductance, μmhos/cm x 10^4	1.20	1.22	1.25	1.24	1.32	1.44	1.38
Salinity, °/oo	9	9	9	9	9	9	9
Total Inorganic Carbon, mg/l	22	22	22	21	21	21	21
Total Organic Carbon, mg/l	15	14	15	15	16	17	15
Chemical Oxygen Demand, mg/l	87	68	74	71	94	101	82
Biochemical Oxygen Demand, mg/l	< 5	4	< 4	< 5	< 5	< 5	< 4
Alkalinity, mg/l							
P	0	0	0	0	0	0	0
T	114.0	110.2	107.4	105.0	102.6	108.3	104.5
Chlorophyll-a, mg/l	0.139	0.168	0.132	0.050	0.075	0.300	0.150

TABLE 5 (Cont'd)

Physical-chemical Data for Samples Taken From Houston Ship Channel and Barbour's Cut During Mission 192, Test Site 256. Sampling Date, February 4, 1972.

Parameter	Station							
	BC8	BC9	10	11	12	13	14	15
pH	8.1	8.1	8.1	8.0	8.1	7.95	7.9	8.05
Dissolved Oxygen, mg/l	10.1	10.1	10.2	10.1	10.8	10.2	10.1	10.8
Dissolved Oxygen % Saturation	101	101	102	100	107	100	100	107
Temperature, °C;								
Surface	10.4	10.4	10.4	9.8	9.9	9.5	10	9.9
Secchi Disc, in.	14	14	13	10	11	11	11	11
Turbidity J.T.U.	33	31	21	43	40	39	30	51
Specific Conductance, μmhos/cm x 10^4	1.34	1.39	1.39	1.60	1.48	1.45	1.38	1.41
Salinity, °/₀₀	9.5	9.8	10	10	10.3	10.3	10	10
Total Inorganic Carbon, mg/l	21	21	21	21	21	21	21	21
Total Organic Carbon, mg/l	15	14	15	16	15	16	17	18
Chemical Oxygen Demand, mg/l	72	77	84	96	76	89	98	123
Biochemical Oxygen Demand, mg/l	< 4	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Alkalinity, mg/l								
P	0	0	0	0	0	0	0	0
T	105.0	101.6	104.5	102.6	110.2	111.2	110.2	109.2
Chlorophyll-a, mg/l	0.068	0.118	0.142	0.211	0.182	0.200	0.182	0.197

TABLE 6

Relative Density Gradient Scheme For Datacolor Prints - Figures 8-11.

Color	Relative Density
Figures 8 and 9	
Purple	1.65
	1.51
	1.37
	1.22
	1.07
	0.92
	0.77
	0.63
Solid Blue	0.49
Figures 10 and 11	
Purple	1.37
	1.22
	1.07
	0.92
	0.77
	0.63
	0.49
	0.35
Light Blue	0.21

FIGURE 8

DATACOLOR CODE FOR FIGURE 9

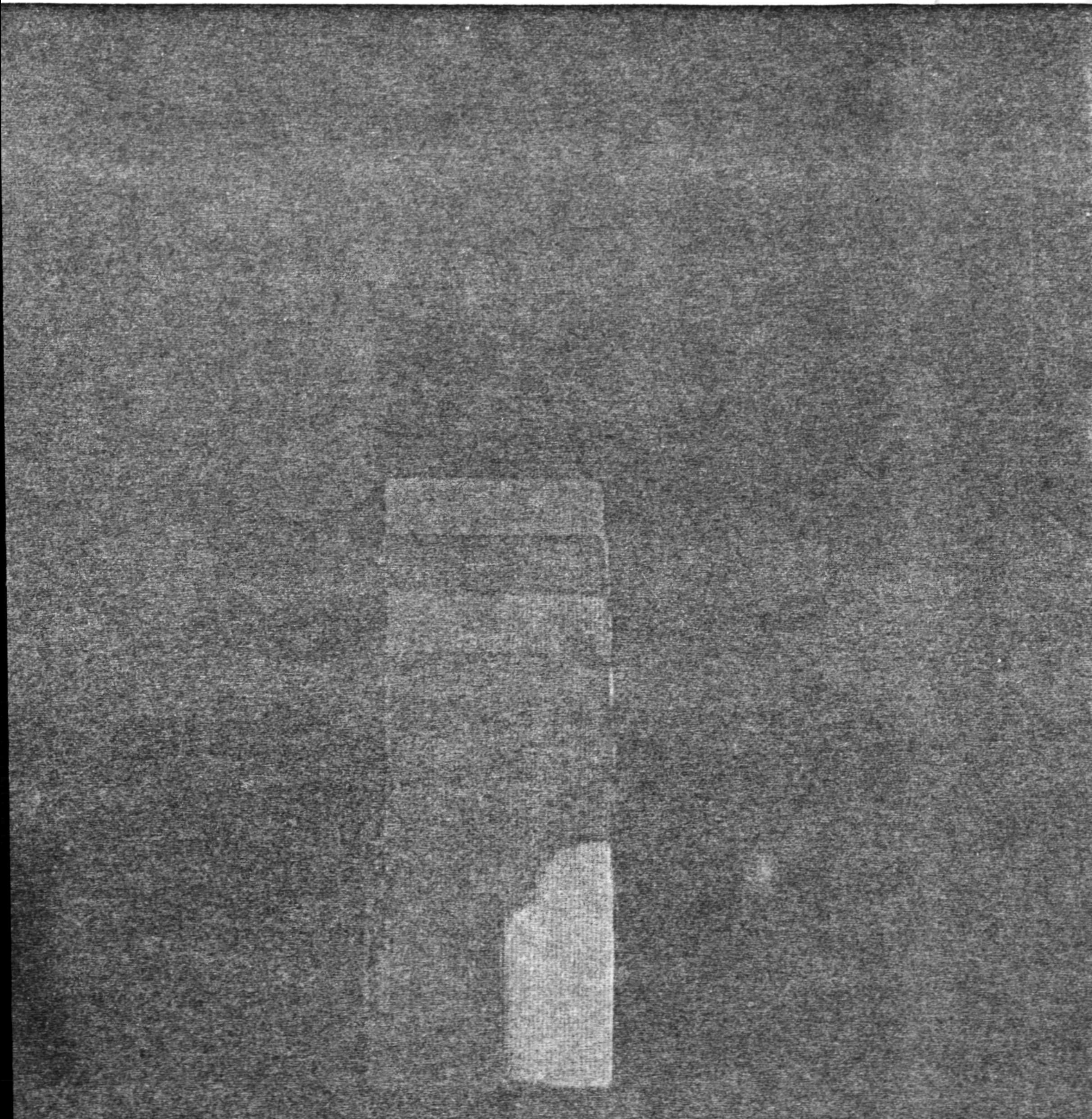


FIGURE 9

DATACOLOR PRINT

DATE: FEBRUARY 4, 1972

MISSION 192, SITE 256, FLIGHT 5

CAMERA: KA62

ROLL 44

FILM TYPE: 2402

W/O 6936

FRAME 0091

FIGURE 10

DATACOLOR CODE FOR FIGURE 11

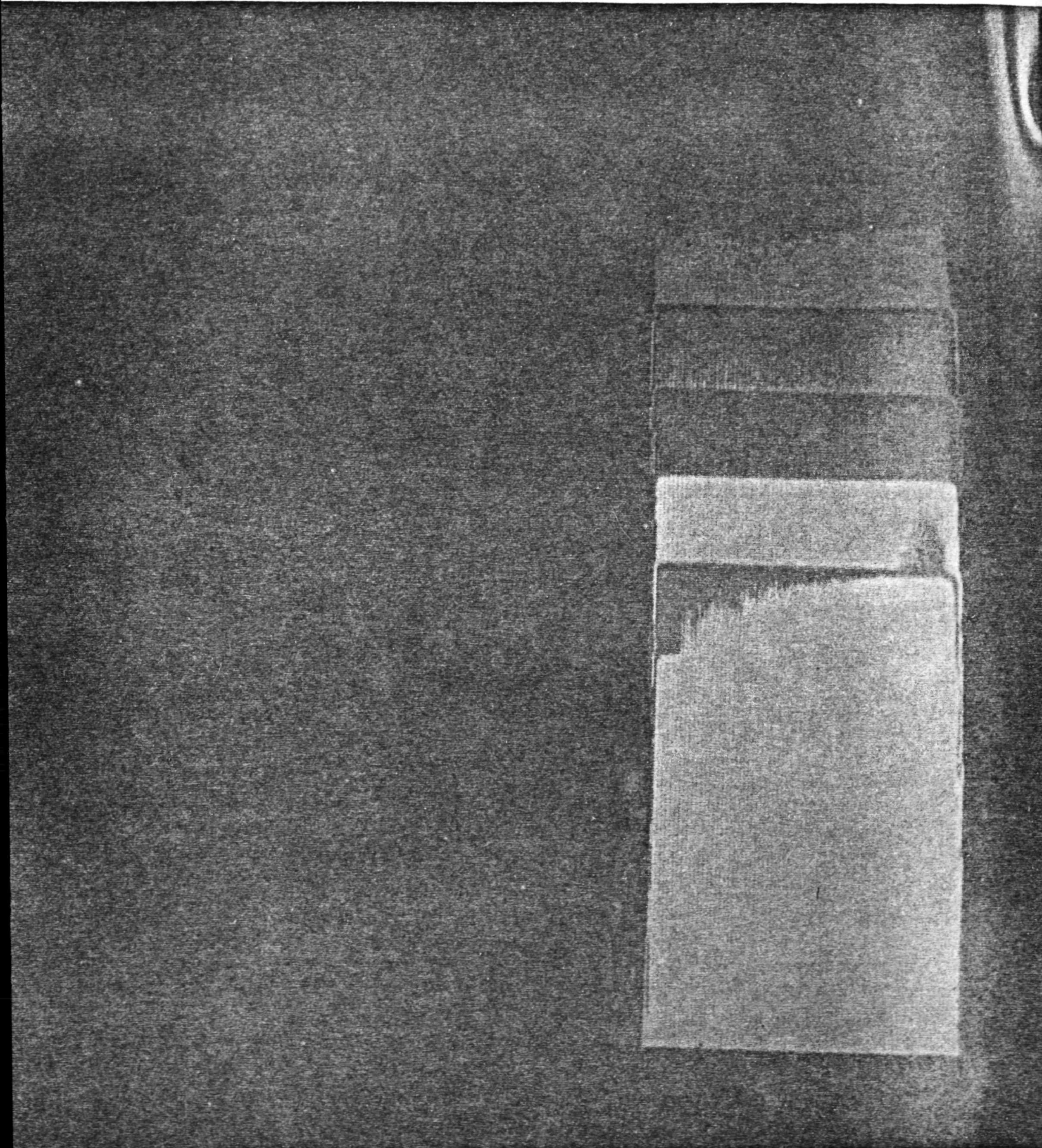


FIGURE 11

DATACOLOR PRINT

DATE: FEBRUARY 4, 1972

MISSION 192, SITE 256, FLIGHT 5

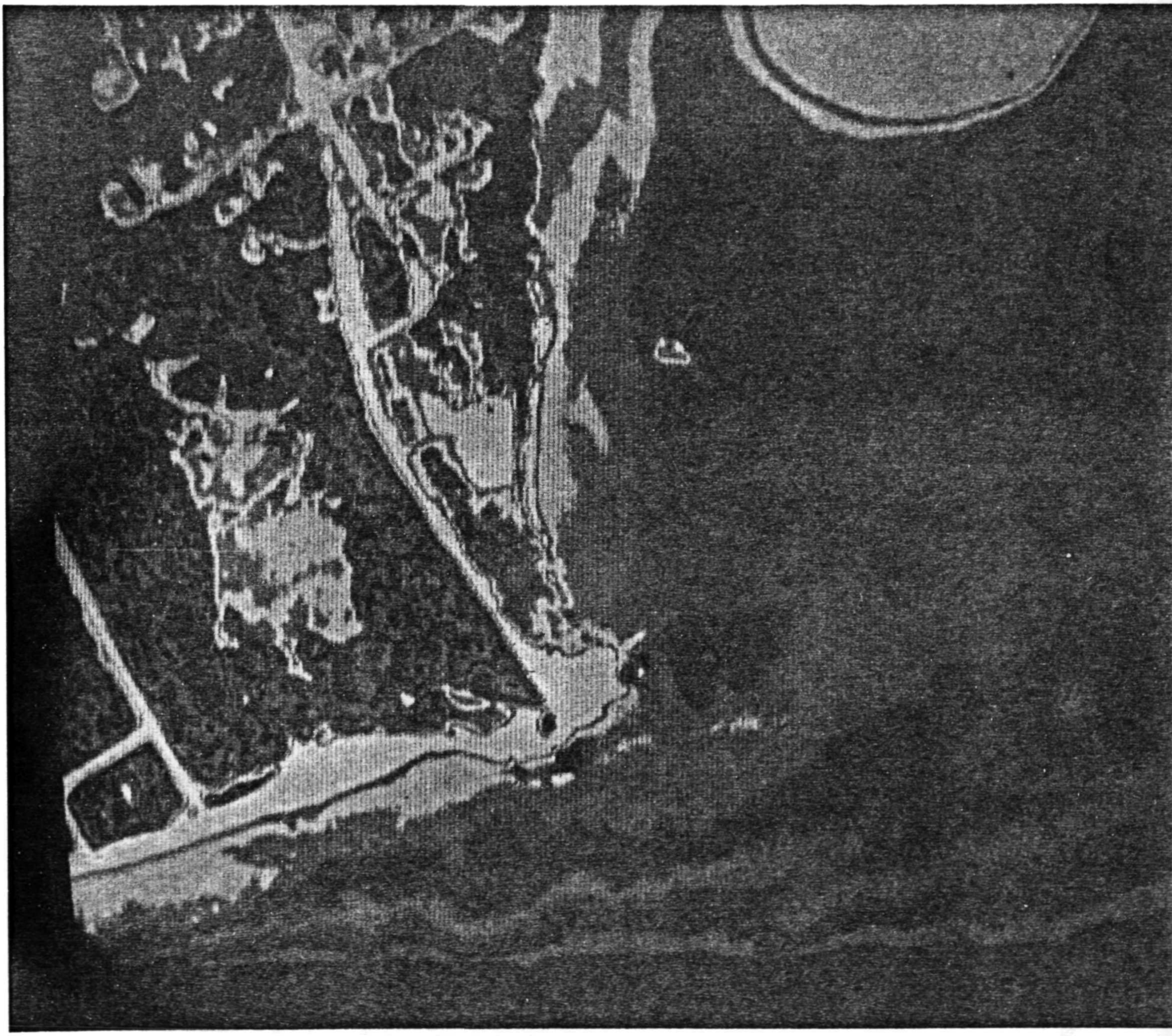
CAMERA: KA62

ROLL 44

FILM TYPE: 2402

W/O 6936

FRAME 0092



KA62 imagery developed from this survey, was subjected to density interpretation by two instrumental methods. The first was the Spatial Data Systems Datacolor Machine, VC-20 Series. The results of this imagery interpretation are presented in Figures 8, 9, 10, and 11, with the interpretation of the color coding network presented in Table 6. Each datacolor interpretation had similar color coding applied but different density ranges, hence, the importance of separate application of the data in Table 6. The density gradients in Figures 9 and 11 confirm some of the reported physical and chemical data presented earlier. The entrance to Barbour's Cut and the area near Station BC6 appeared as film density with the higher gradients. The Channel area between Morgan Point and Atkinson Island demonstrated typical laminar flow patterns. Depth patterns undoubtedly affected the outcome of both the physical-chemical and Datacolor imagery interpretation but cannot be conclusively integrated by the data presented thus far. Correlations between Datacolor imagery and laboratory measured parameters will be presented later in the report.

Figures 12 through 14 present three sections of the test site as interpreted by the Isodensitracer from B&W IR film (0.68μ - 0.90μ) as taken with Camera #4 of the KA62 series. The codes are identical for these three printouts

FIGURE 12

ISODENSITRACER RECORDING

NASA PRINT S-72-50489

DATE: FEBRUARY 4, 1972

MISSION 192, SITE 256, FLIGHT 5

CAMERA: KA62

ROLL 44

FILM TYPE: 2402

W/O 6936

FRAME 0091

Isodensitracer Recording
Imager: KA 62 (0.68-0.90μ)
Magnification: 5X
Sample Location: Houston Ship Channel
and Barbour's Cut
Sample Date: 2-4-72

FIGURE 13

Isodensitracer Recording

NASA S-72-50491

Date: February 4, 1972

Mission 192, Site 256, Flight 5

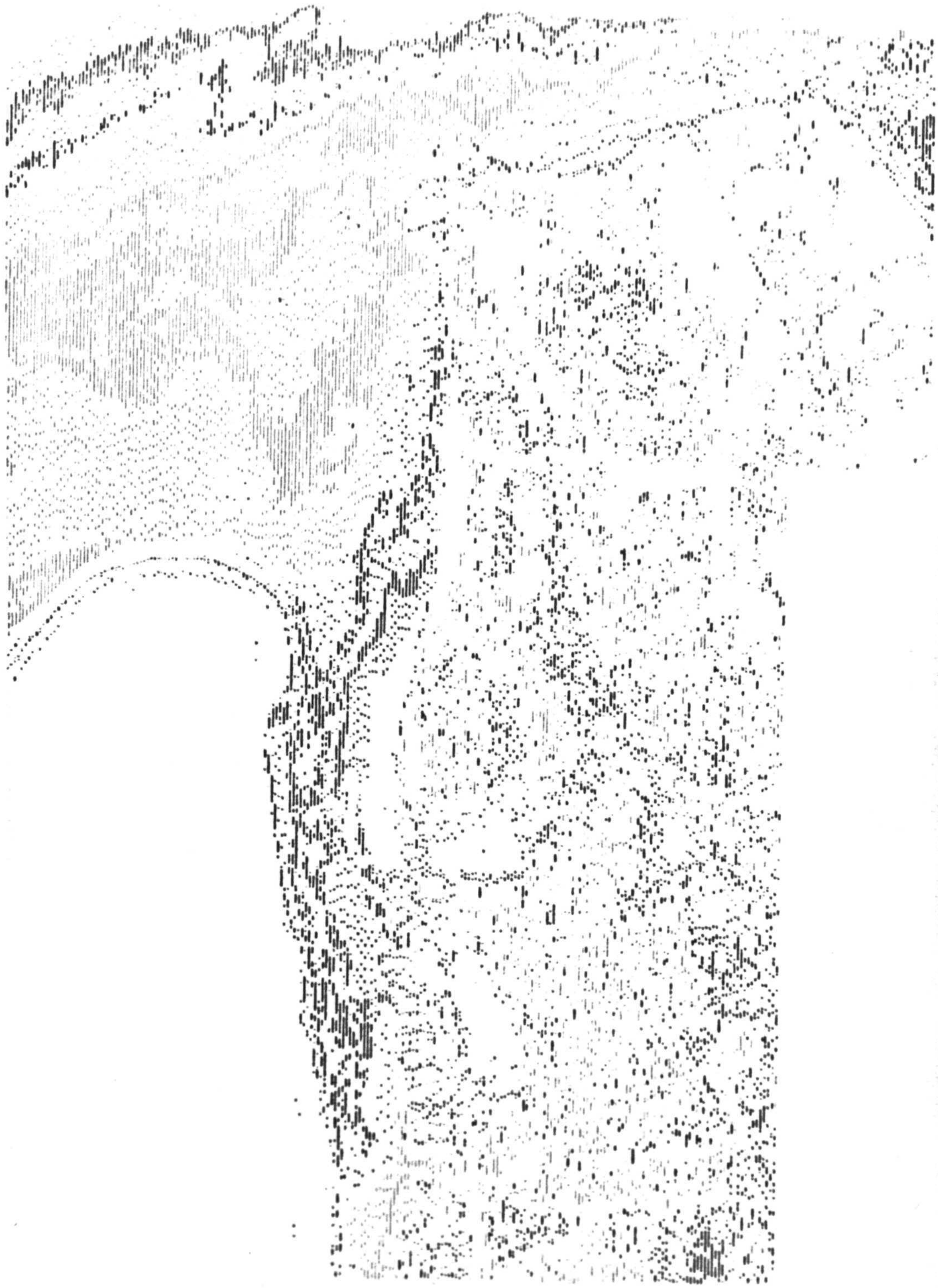
Camera: KA62

Roll 44

Film Type: 2402

W/O 6936

Frame 0092



Isodensitracer Recording
Imager: KA 62 (0.68-0.90μ)
Magnification: 2X
Sample Location: Houston Ship Channel and Barbour's Cut
Sample Date: 2-4-72

FIGURE 14

ISODENSITRACER RECORDING

NASA S-72-50490

DATE: FEBRUARY 4, 1972

MISSION 192, SITE 256, FLIGHT 5

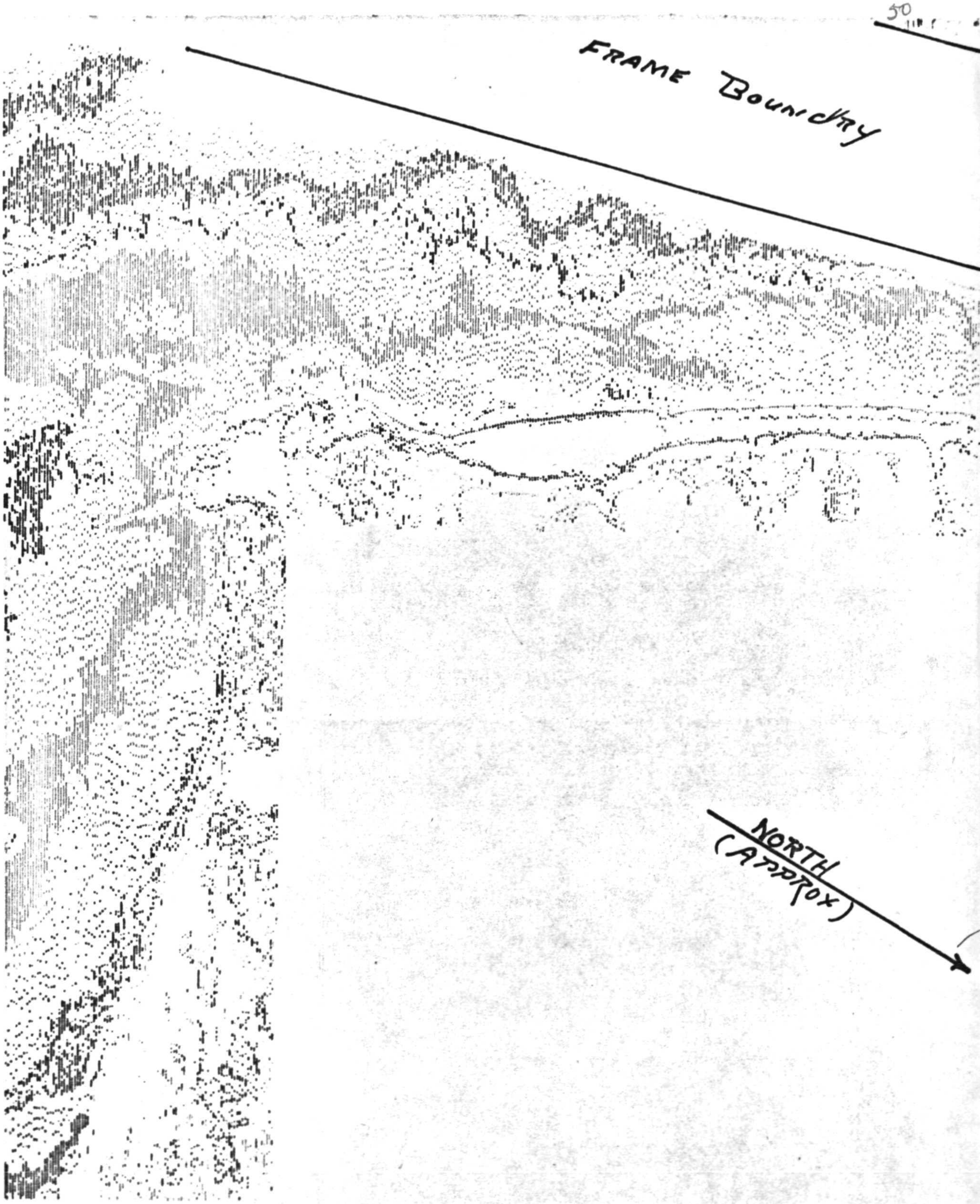
CAMERA: KA62

ROLL 44

FILM TYPE: 2402

W/O 6936

FRAME 0092



Isodensitracer Recording
Imager: KA 62 (0.68-0.90µ)
Magnification: 5X
Sample Location: Houston Ship Channel
and Barbour's Cut
Sample Date: 2-4-72

to those presented in Table 3. Figure 12 shows the Morgan Point and adjacent Channel area; Figures 13 and 14 show two segments of the Barbour's Cut area. Delineation of current and flow patterns as depicted by the IR film densities are clear in these prints. The waters near Spilmans Island, (Station BC6) clearly were interpreted by the instrumentation as exhibiting greater density than the cross sectional area of the Cut itself.

Linear regression analyses were applied to the density interpretation printouts of the Datacolor processes (Figures 8-11), the Isodensitracer printouts (Figures 12-14), and the values cited in Table 5 for organic carbon, turbidity, C.O.D., Secchi Disc Values, and the Chlorophyll-a concentrations existing in the test site waters on February 4, 1972. Values for the entire water area and for the Channel area, only, were computed. These data are presented in Figures 15-19, and Figures 20-24 respectively. Those values for the Isodensitracer densities are presented in Figures 25 through 29. The following table summarizes the correlation coefficients of the regression analyses:

Parameter	Barbour's Cut And Channel Area (Isodensitracer)	(Datacolor)	Channel Area Only (Datacolor)	Figure Number
Org. Carbon	-0.215	-0.496	-0.596	15,20,25
Turbidity	-0.179	-0.174	-0.631	16,21,26
C.O.D.	-0.109	-0.425	-0.390	17,22,27
Secchi	-0.229	+0.252	+0.882	18,23,28
Chl-a	-0.014	+0.165	-0.872	19,24,29

Imagery interpretation of film densities obviously followed a reciprocal relationship in some cases. However, those data are as valuable as the positive, elevated, values for the coefficients cited above. Excepting the value for C.O.D., the data shown for the Channel area above as compared to the entire area showed a significantly higher degree of correlation with quantity vs density. For all practical purposes, considering the standard deviations in the tests themselves compared with the difficulty encountered in obtaining the I^2S and Datacolor differential images, the two sets of two parameters each which deserve close observation are those for Organic Carbon vs C.O.D., and Turbidity vs Secchi Disc Values.

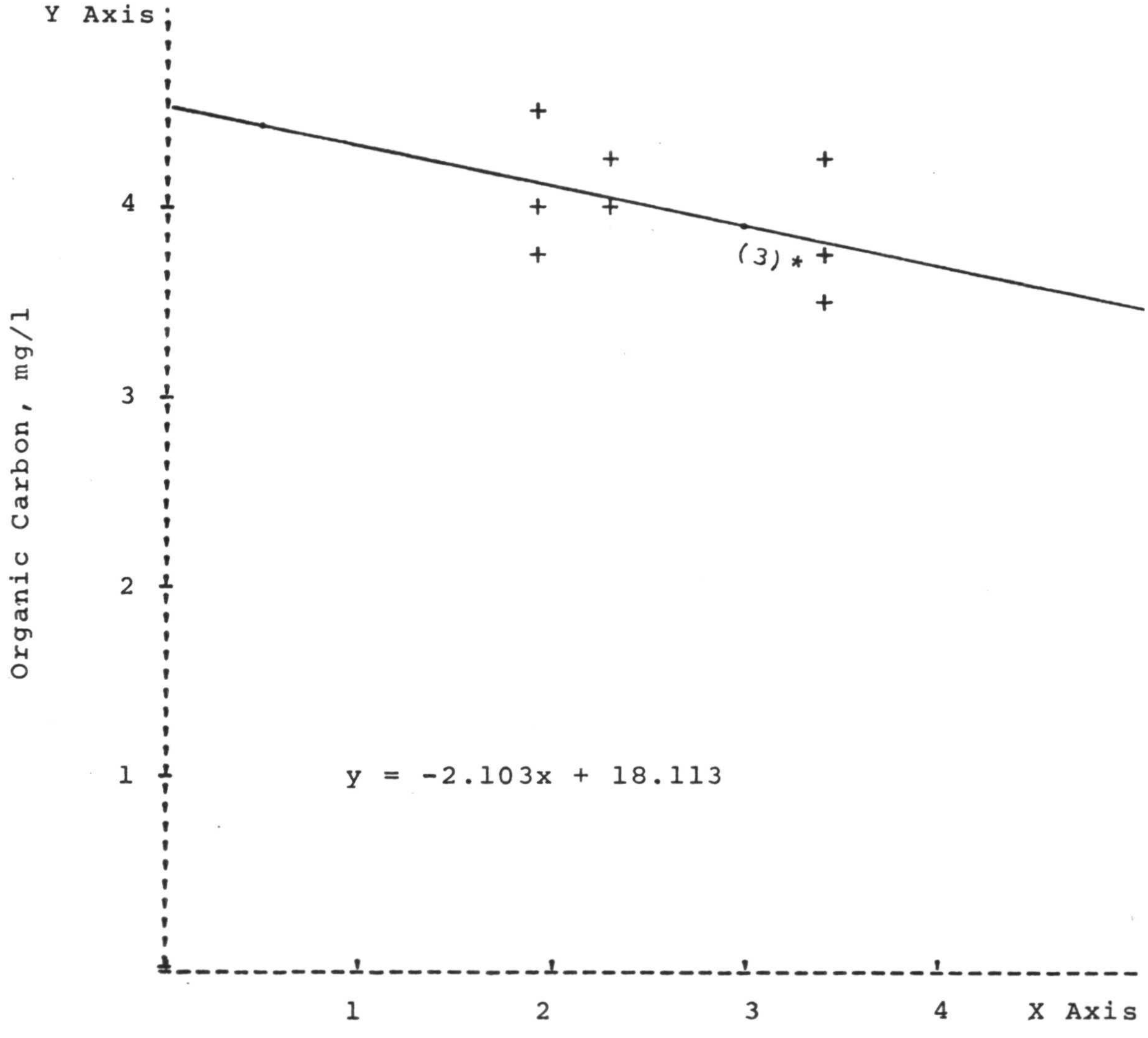
As shown by the data representing the October Survey, most of the organic functional groups in the waters were developed by the (approximately) 3.4μ band on the Infrared Spectrophotometer. These data are presented in Table 7 and

FIGURE 15

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and the organic carbon content of field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = 18.113$ $r = -.496$

$\hat{a}(1) = -2.103$ $S(y.x) = 1.013$

One X Axis unit = 0.40 $n = 10$

One Y Axis unit = 4.00

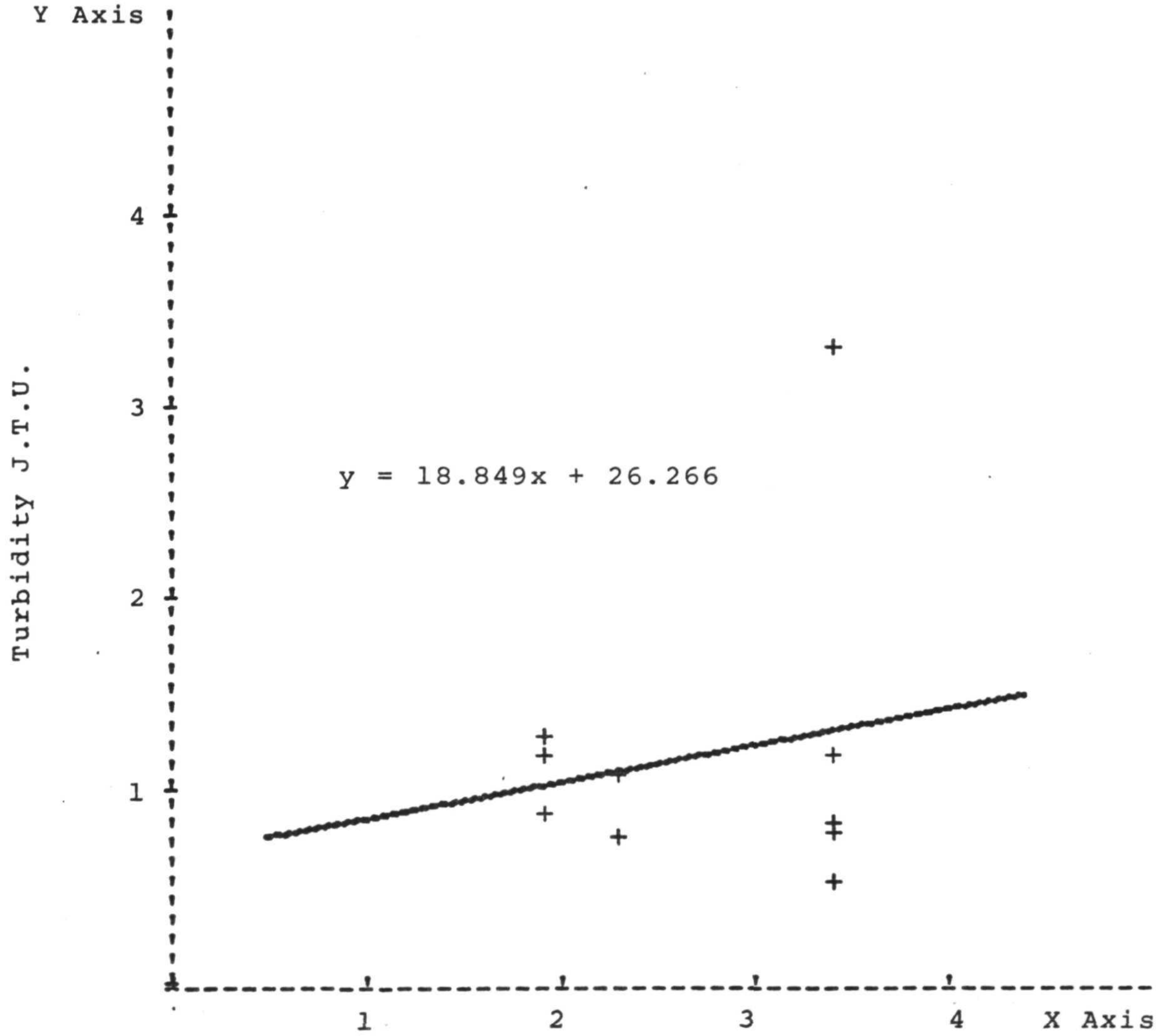
Data Points Represented = BC4, BC5, BC6, BC7, BC8, BC9, 10, 11, 14, 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

* Three sets of coordinates fell on this point

FIGURE 16

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and turbidity values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = 26.266$ $r = .174$

$\hat{a}(1) = 18.849$ $S(y.x) = 29.239$

One X Axis unit = 0.40 $n = 10$

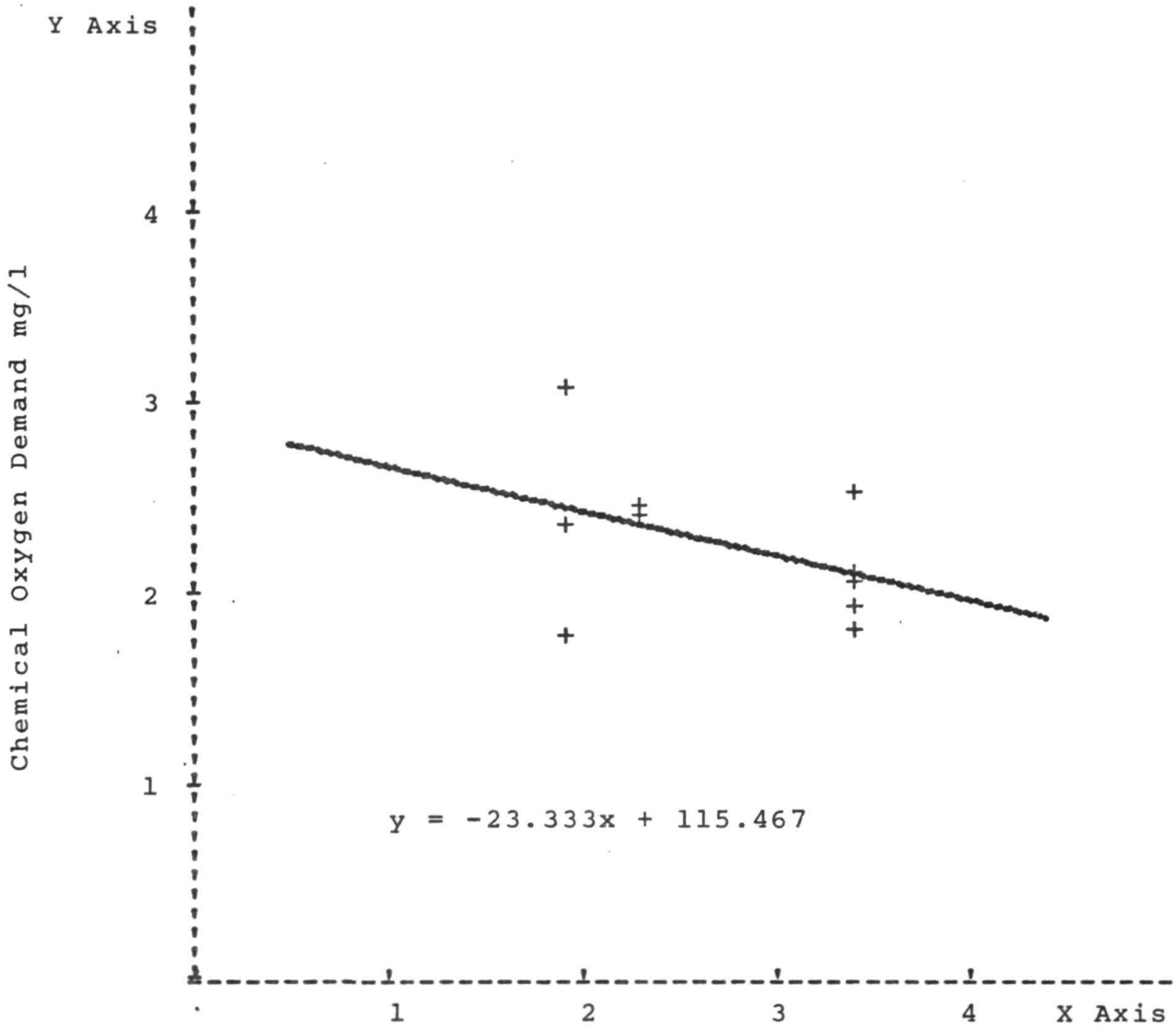
One Y Axis unit = 40.00

Data Points Represented = BC4, BC5, BC6, BC7, BC8, BC9, 10, 11, 14, 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 17

Linear Regression Analysis
y = a(0) + a(1)x
Correlation between relative film densities from KA62 Black-and-White image and chemical oxygen demand values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

a(0) = 115.467 r = -.425

$\hat{a}(1)$ = -23.333 S(y.x) = 13.467

One X Axis unit = 0.40 n = 10

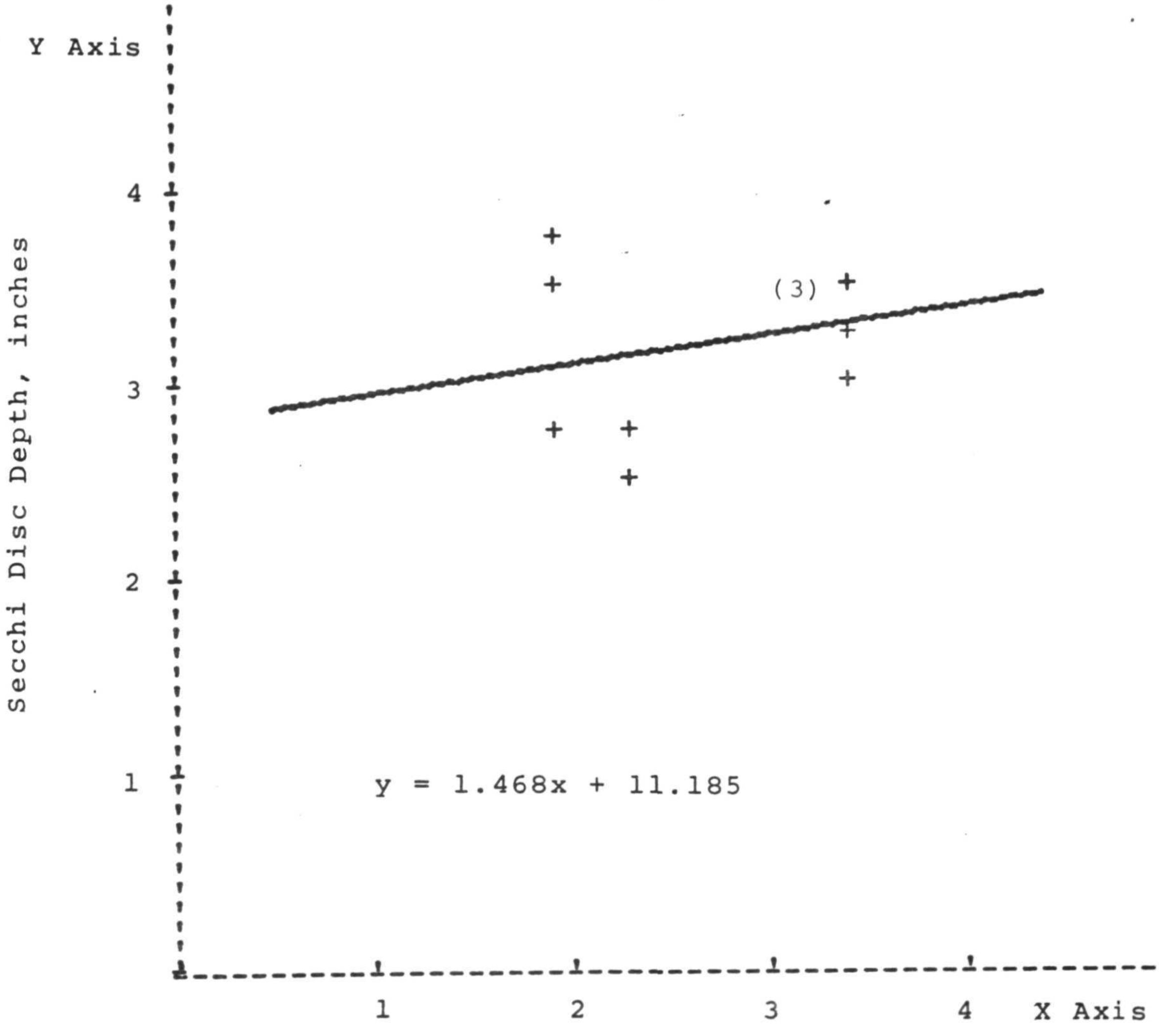
One Y Axis unit = 40.00

Data Points Represented = BC4, BC5, BC6, BC7, BC8, BC9, 10, 11, 14, 15.

Conclusion About Hypothesis, $\hat{a}(1)$ = 0; Not Rejected

FIGURE 18

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and Secchi Disc readings from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = 11.185$ $\qquad$ $r = .252$

$\hat{a}(1) = 1.468$ $\qquad$ $S(y.x) = 1.548$

One X Axis unit = 0.40 $\qquad$ $n = 10$

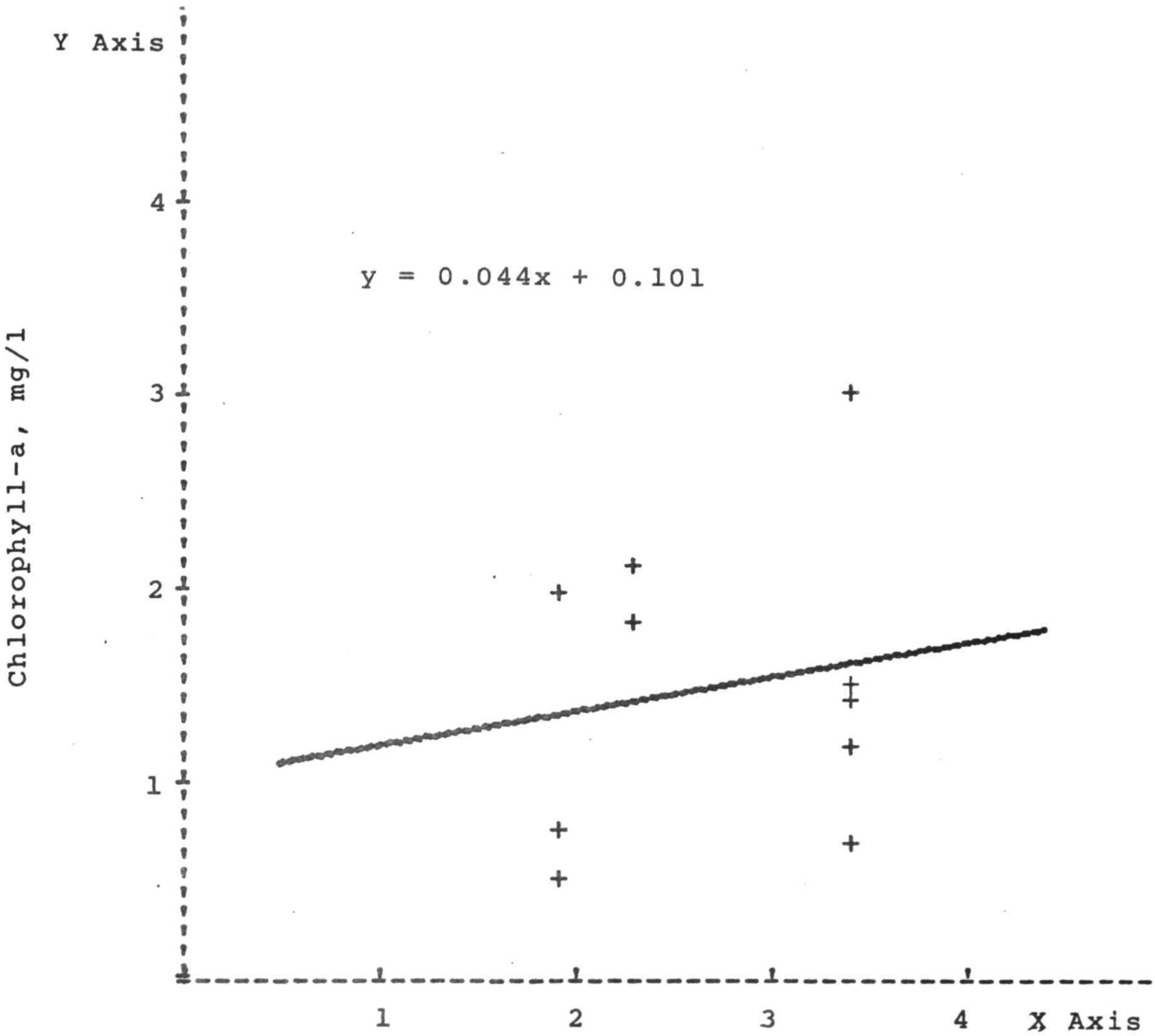
One Y Axis unit = 4.00

Data Points Represented = BC4, BC5, BC6, BC7, BC8, BC9, 10, 11, 14, 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 19

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and chlorophyll-a values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = .101$ $r = .165$

$\hat{a}(1) = .044$ $S(y.x) = .072$

One X Axis unit = 0.40 n = 10

One Y Axis unit = 0.10

Data Points Represented = BC4, BC5, BC6, BC7, BC8, BC9, 10, 11, 14, 15.

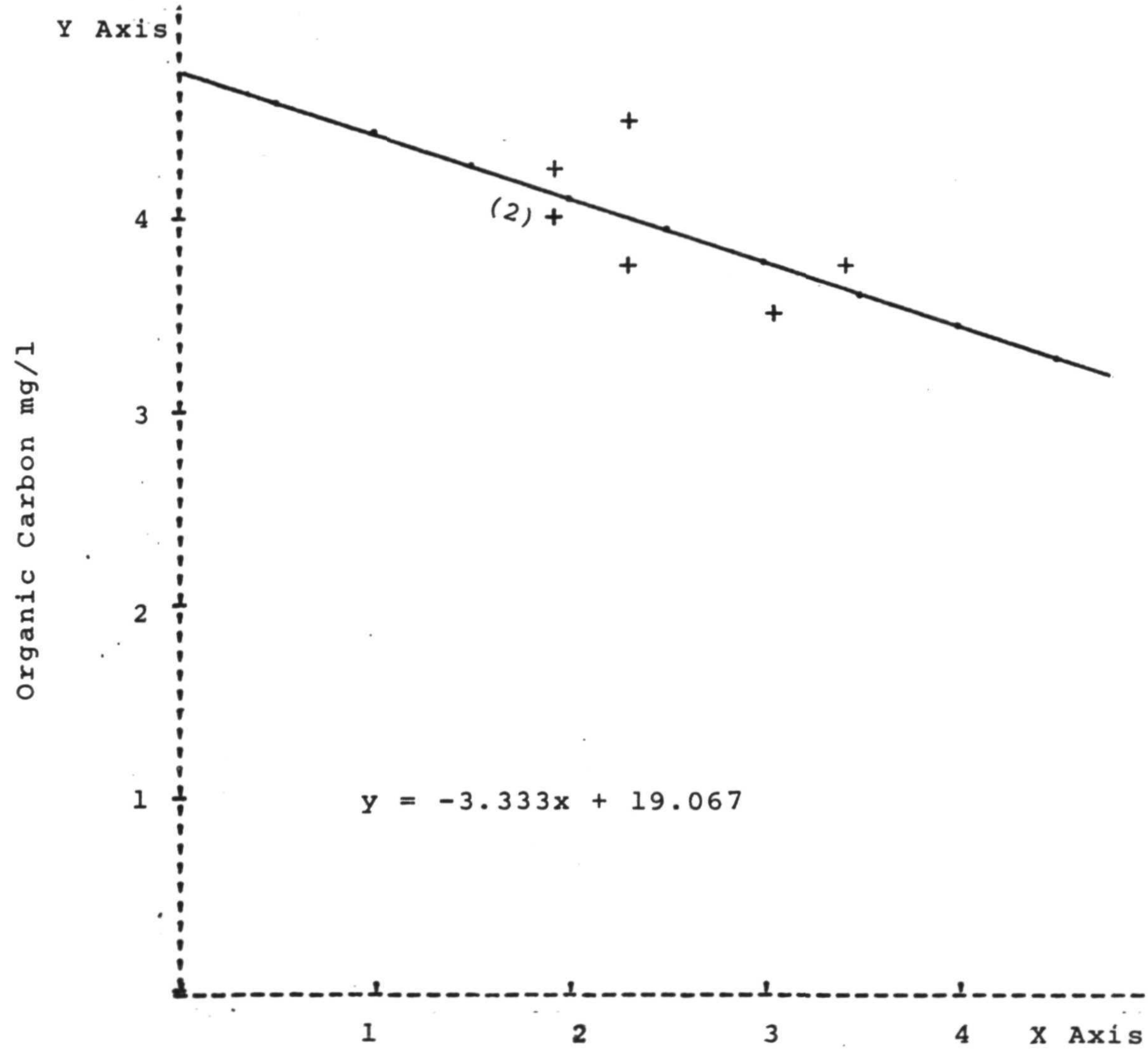
Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 20

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and the organic carbon content of field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

a(0) = 19.067 r = -.596

â(1) = -3.333 S(y.x) = 1.000

One X Axis unit = 0.40 n = 7

One Y Axis unit = 4.00

Data Points Represented = BC9, 10, 11, 12, 13, 14, 15.

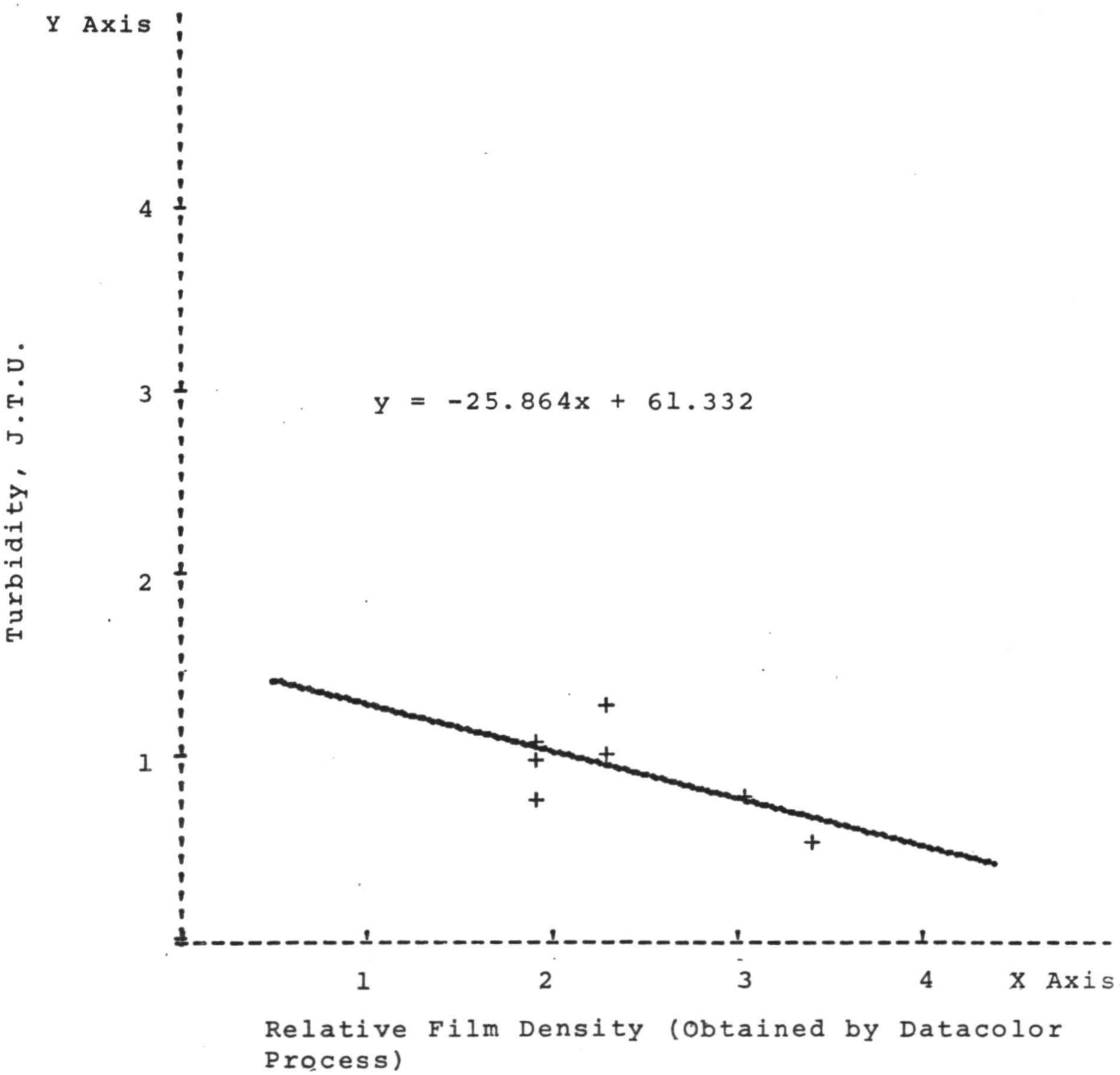
Conclusion About Hypothesis, â(1) = 0; Not Rejected

FIGURE 21

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and turbidity values from field samples collected on February 4, 1972



a(0) = 61.332   r = -.631

â(1) = -25.864   S(y.x) = 7.086

One X Axis unit = 0.40   n = 7

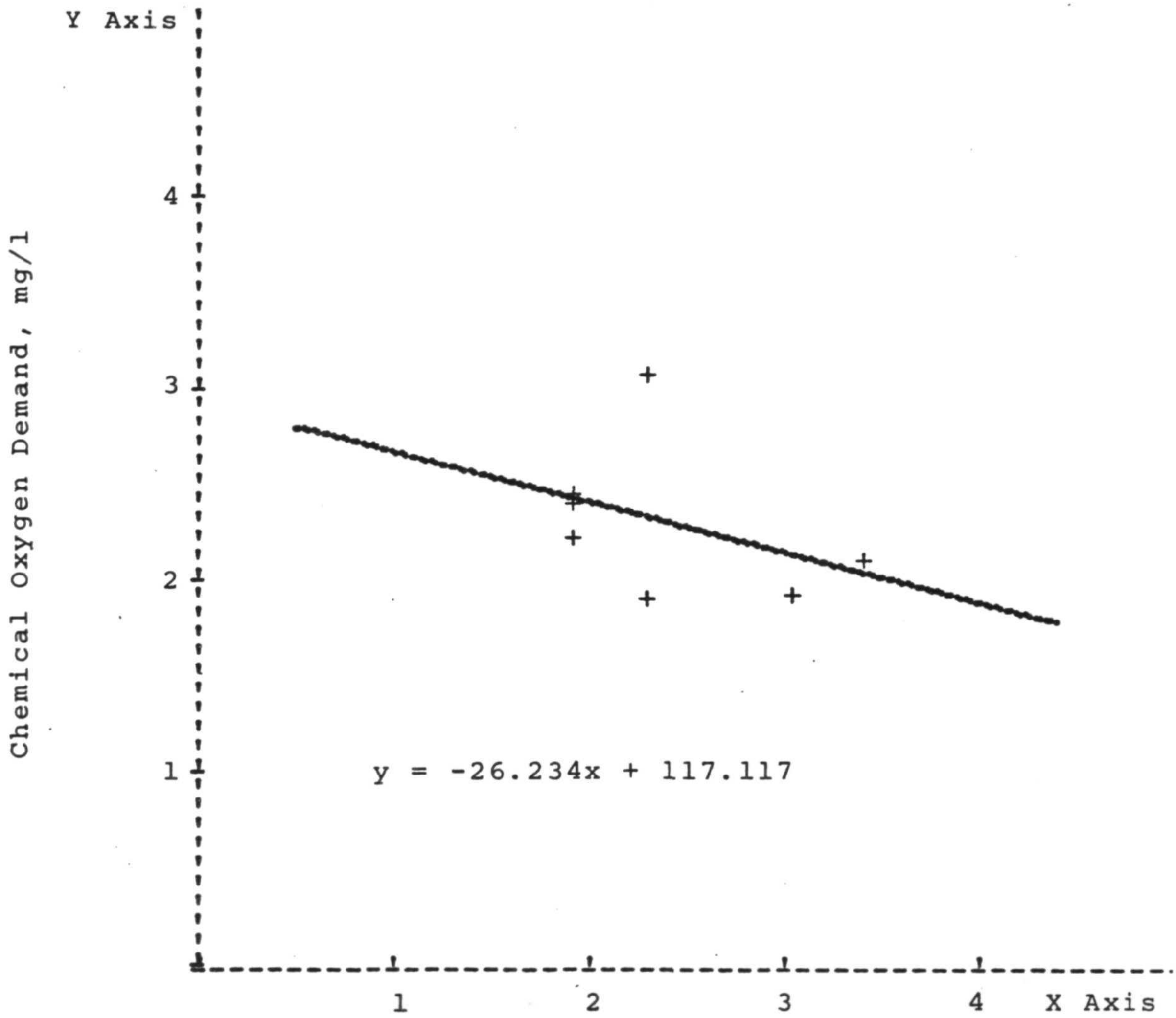
One Y Axis unit = 40.00

Data Points Represented = BC9, 10, 11, 12, 13, 14, 15.

Conclusion About Hypothesis, â(1) = 0; Not Rejected

FIGURE 22

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and chemical oxygen demand values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = 117.117$ $\quad$ $r = -.390$

$\hat{a}(1) = -26.234$ $\quad$ $S(y.x) = 13.773$

One X Axis unit = 0.40 $\quad$ $n = 7$

One Y Axis unit = 40.00

Data Points Represented = BC9, 10, 11, 12, 13, 14, 15.

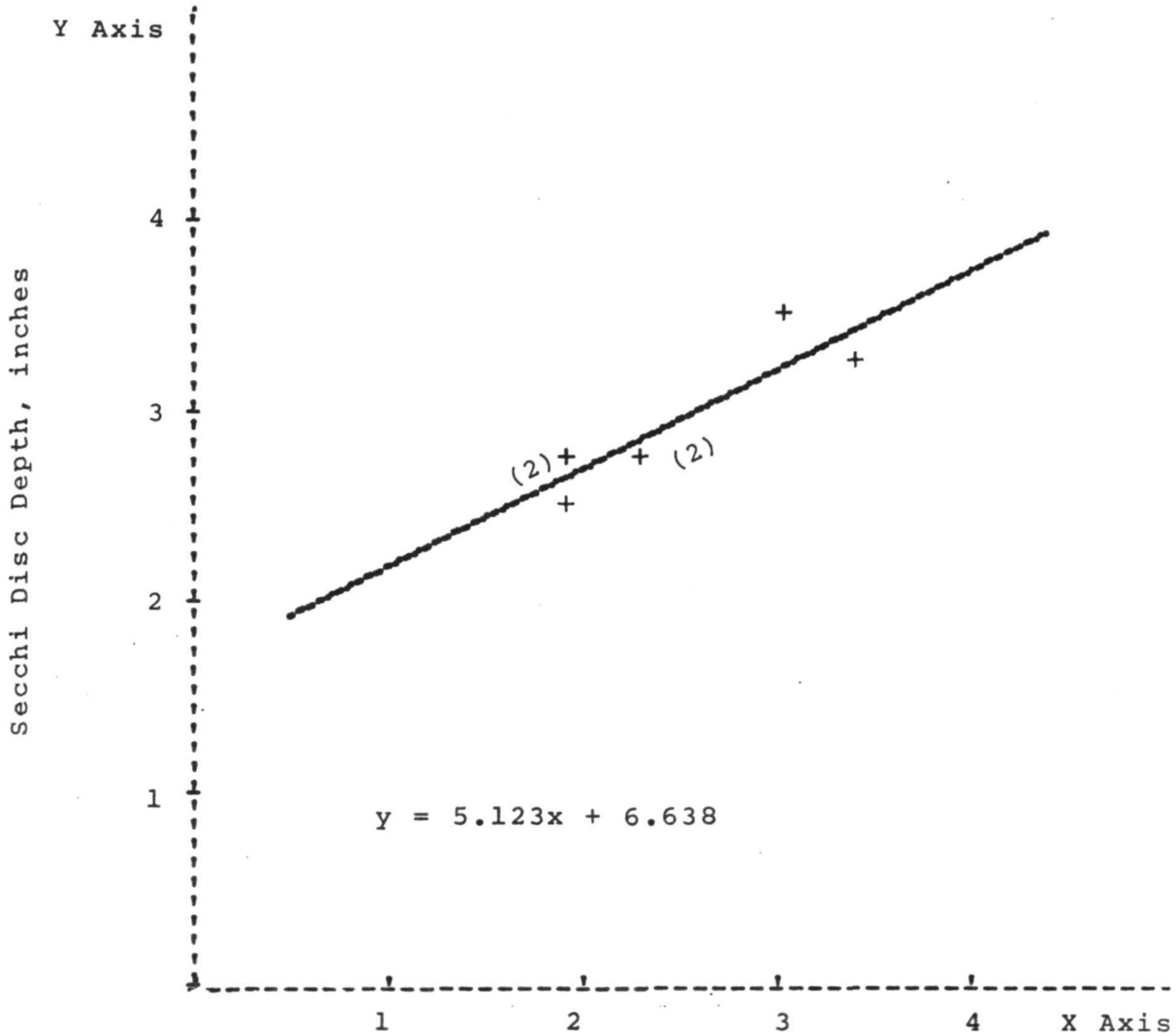
Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 23

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and Secchi Disc readings from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

$a(0) = 6.638$ $r = .882$

$\hat{a}(1) = 5.123$ $S(y.x) = .610$

One X Axis unit = 0.40 $n = 7$

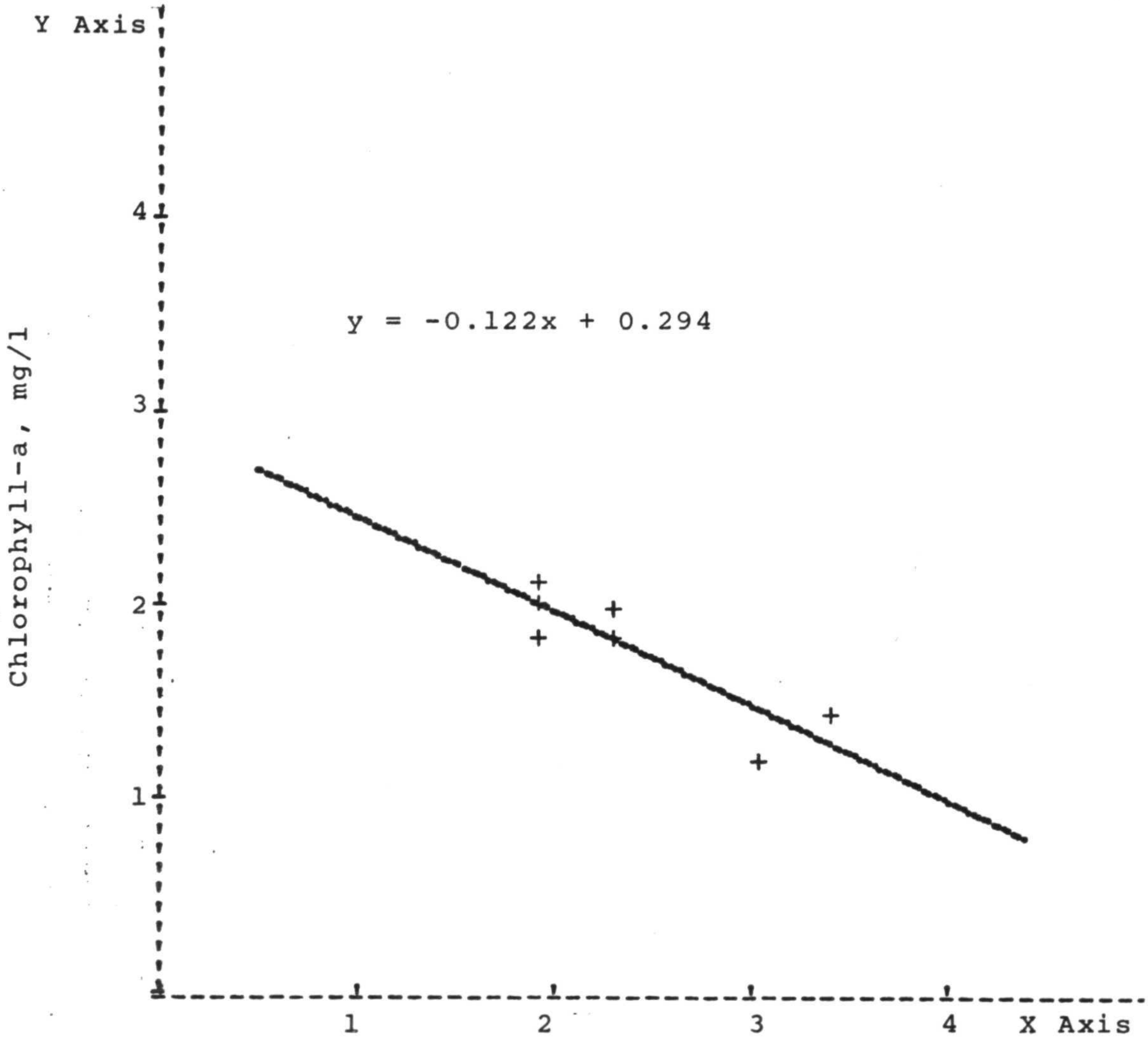
One Y Axis unit = 4.00

Data Points Represented = BC9, 10, 11, 12, 13, 14, 15

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Reject at 5% Level, Reject at 1% Level.

FIGURE 24

Linear Regression Analysis
y = a(0) + a(1)x
Correlation between relative film densities from KA62 Black-and-White image and chlorophyll-a values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Datacolor Process)

a(0) = 0.294 r = -0.872

â(1) = -0.122 S(y.x) = 0.015

One X Axis unit = 0.400 n = 7

One Y Axis unit = 0.100

Data Points Represented = BC9, 10, 11, 12, 13, 14, 15.

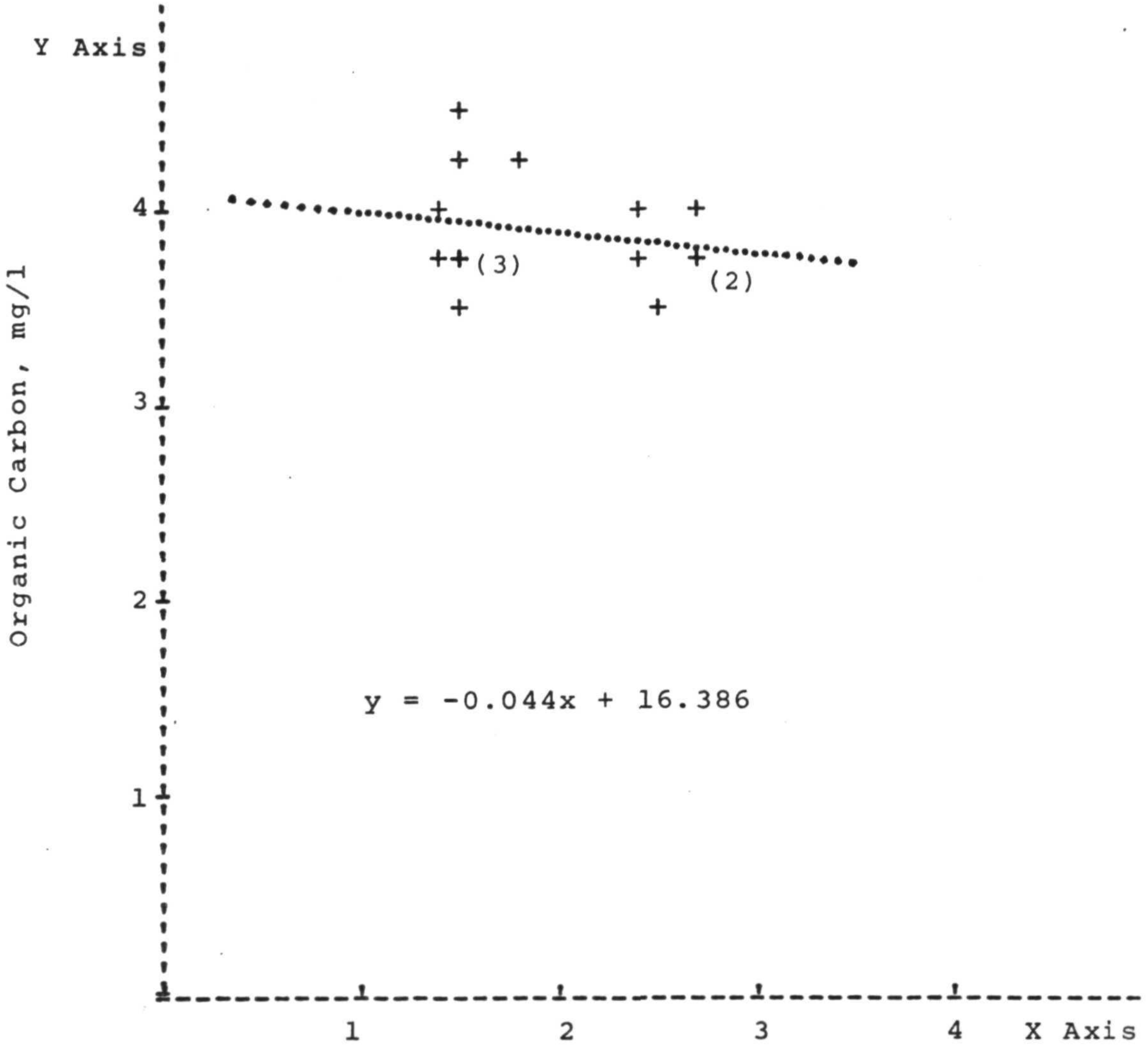
Conclusion About Hypothesis, â(1) = 0; Reject at 5% Level, Not Rejected at 1% Level.

FIGURE 25

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and the organic carbon content in field samples collected on February 4, 1972



Relative Film Density (Obtained by Isodensitracer Process)

a(0) = 16.386	r = -0.215
â(1) = -.044	S(y.x) = 1.062
One X Axis unit = 10.00	n = 15
One Y Axis unit = 4.00	

Data Points Represented = BC1 through BC9, and 10 through 15.

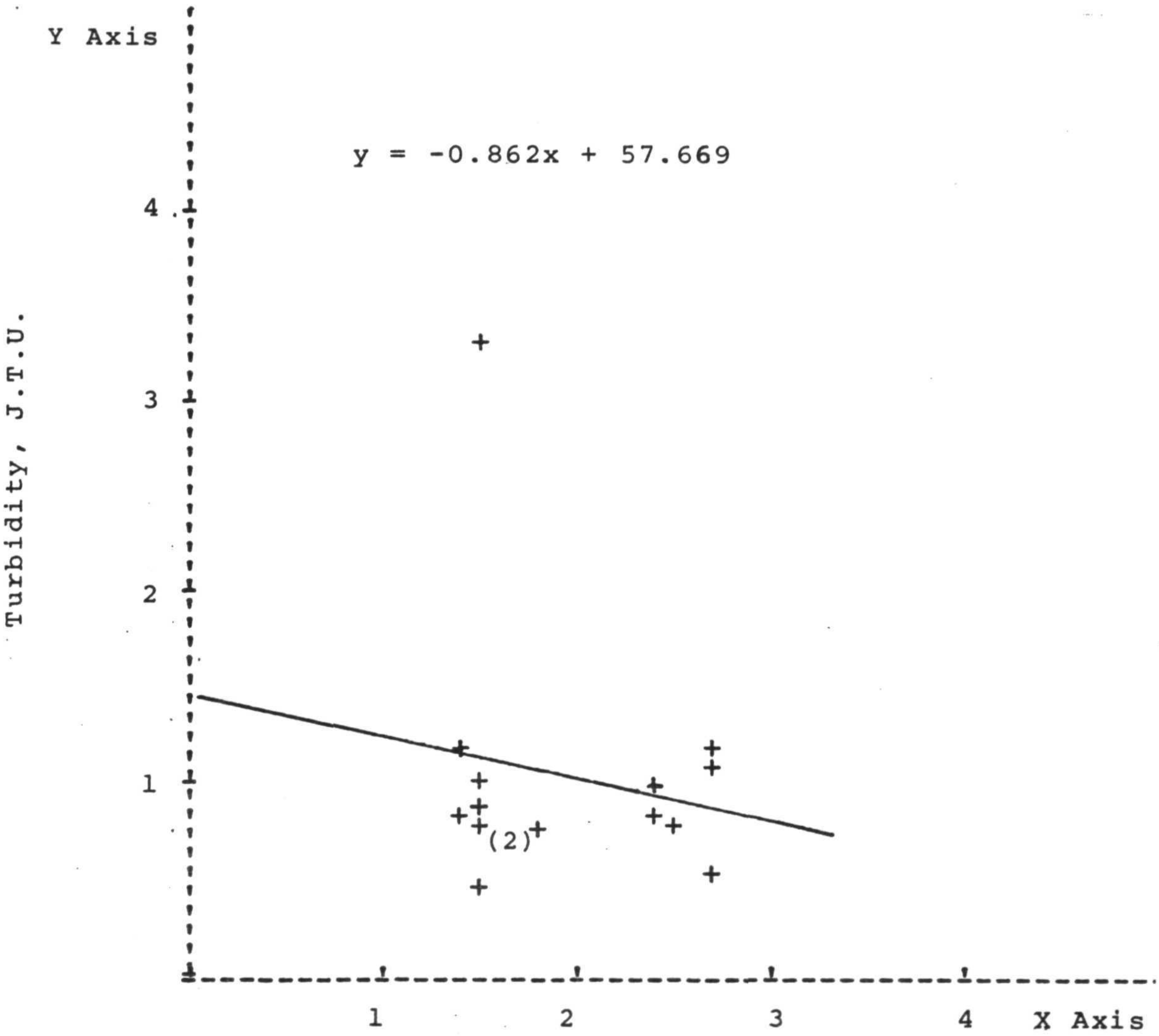
Conclusion About Hypothesis, â(1) = 0; Not Rejected

FIGURE 26

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and turbidity values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Isodensitracer Process)

$a(0) = 57.669$ $\quad r = -.179$

$\hat{a}(1) = -.862$ $\quad S(y.x) = 25.162$

One X Axis unit = 10.00 $\quad n = 15$

One Y Axis unit = 40.00

Data Points Represented = BC1 through BC9, and 10 through 15.

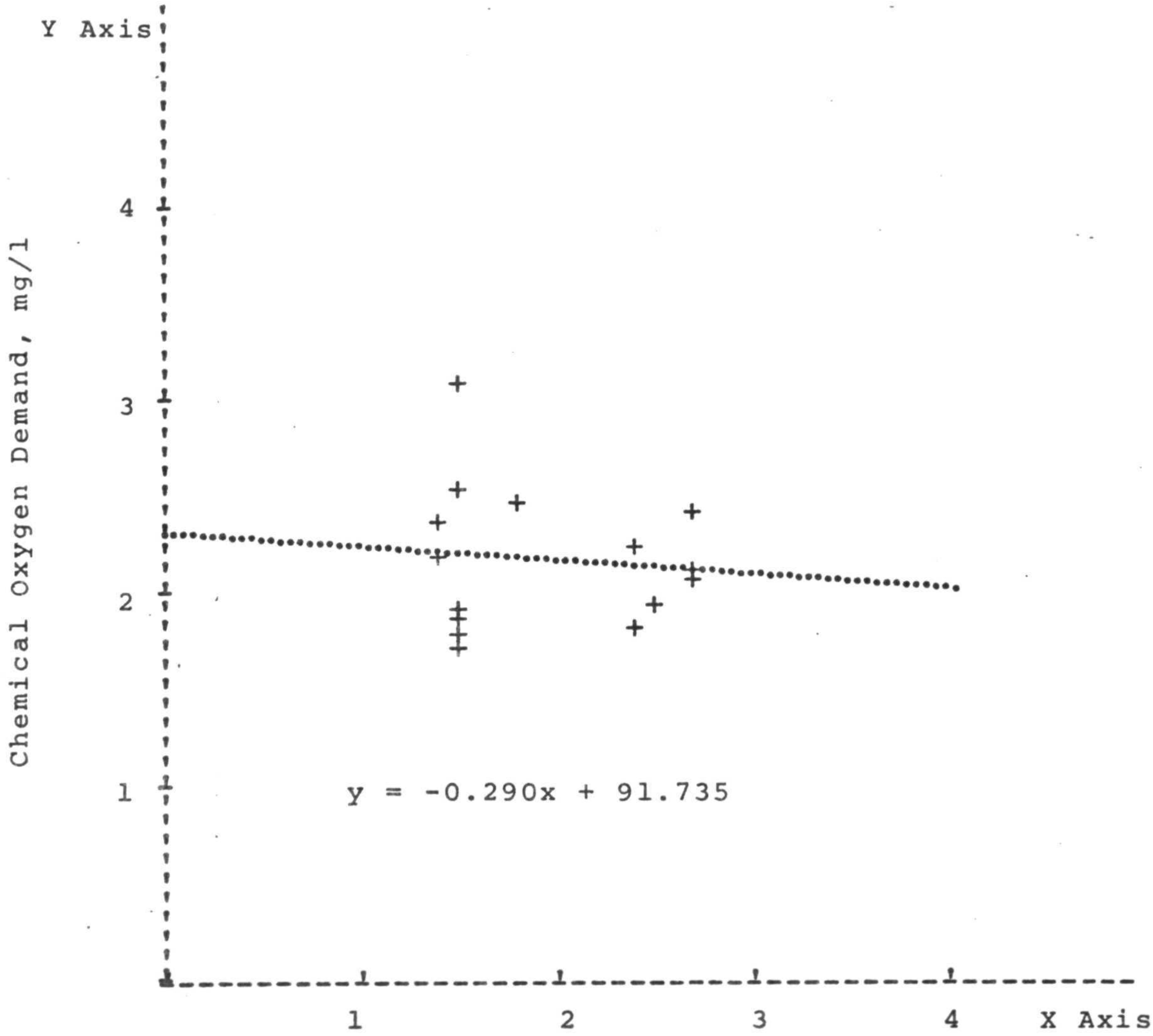
Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 27

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and chemical oxygen demand values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Isodensitracer Process)

$a(0) = 91.735$ $r = -.109$

$\hat{a}(1) = -.290$ $S(y.x) = 14.062$

One X Axis unit = 10.00 $n = 15$

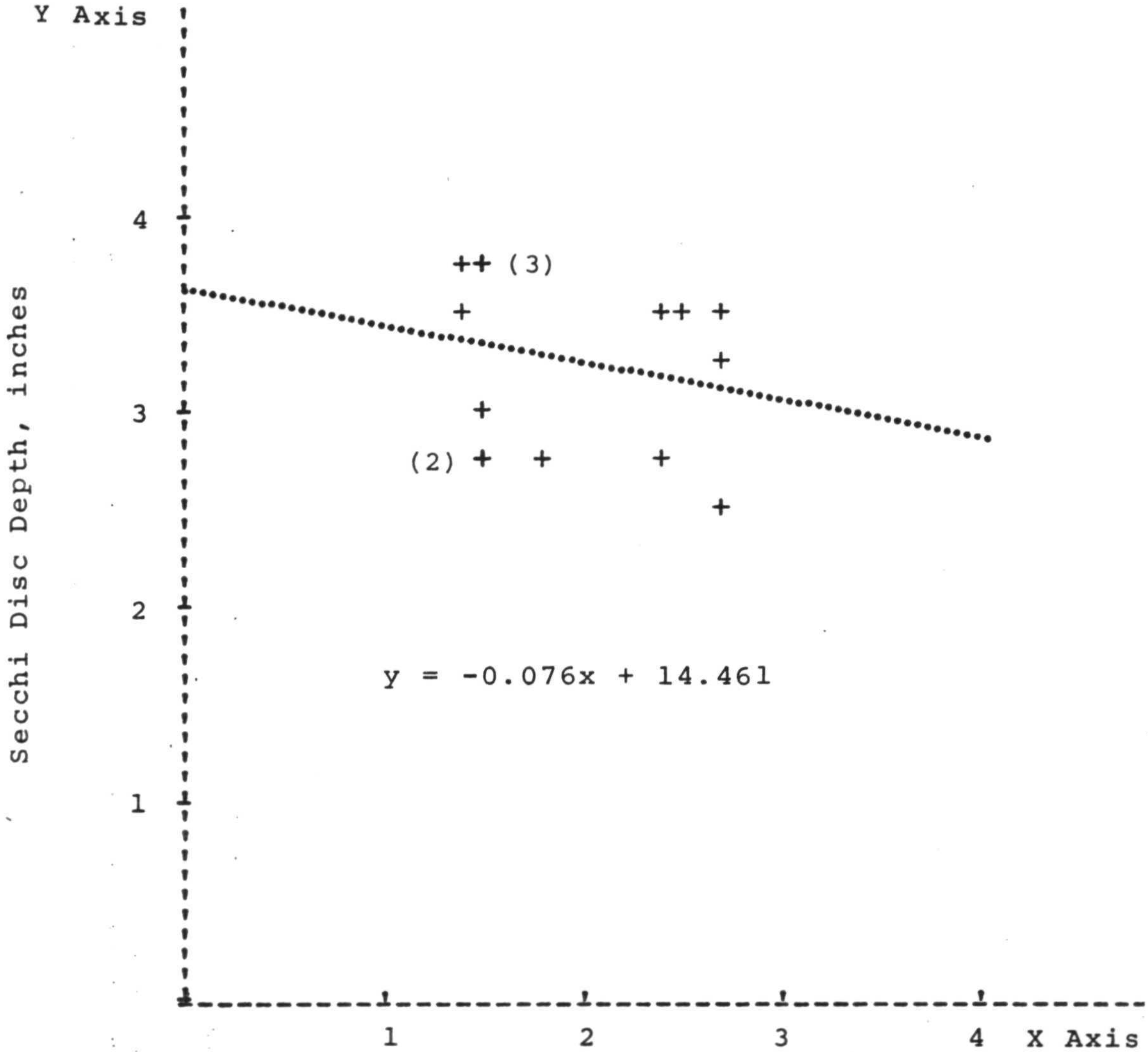
One Y Axis unit = 40.00

Data Points Represented = BC1 through BC9, and 10 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 28

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and Secchi Disc readings from field samples collected on February 4, 1972



Relative Film Density (Obtained by Isodensitracer Process)

$a(0) = 14.461$ $r = -.229$

$\hat{a}(1) = -.076$ $S(y.x) = 1.704$

One X Axis unit = 10.00 $n = 15$

One Y Axis unit = 4.00

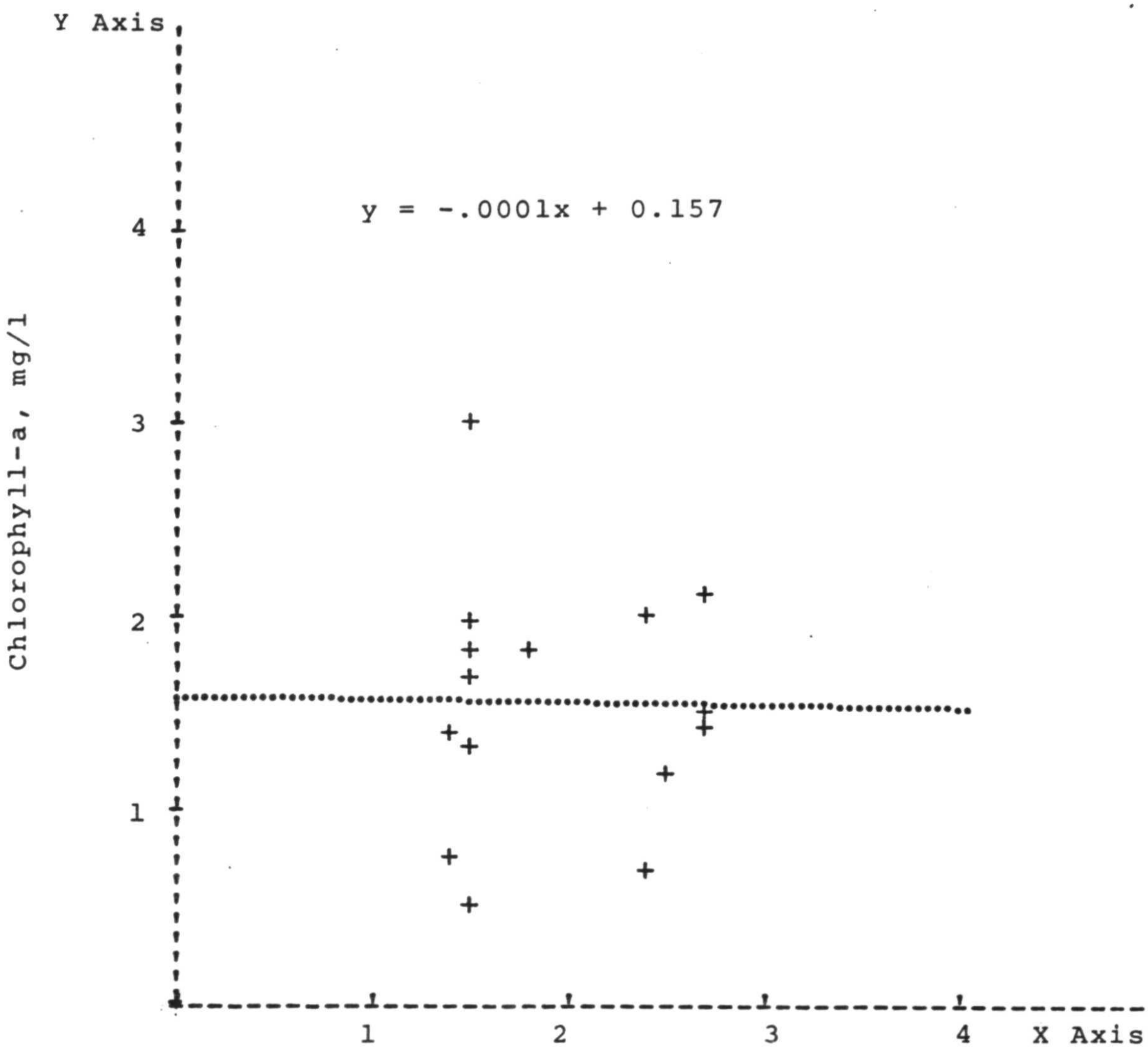
Data Points Represented = BC1 through BC9, and 10 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 29

Linear Regression Analysis
$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and chlorophyll-a values from field samples collected on February 4, 1972



Relative Film Density (Obtained by Isodensitracer Process)

$a(0) = .157$ $r = -.014$

$\hat{a}(1) = -.0001$ $S(y.x) = .062$

One X Axis unit = 10.00 $n = 15$

One Y Axis unit = .10

Data Points Represented = BC1 through BC9, and 10 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

Table 7. Absorption Values For Three IR Spectrophotometric Analysis Techniques; February 4, 1972 Survey.

Station	Reflectance ATR $\sim 5.3\mu$	CCl_4 Extract $\sim 3.4\mu$	KBr Evaporate $\sim 3.4\mu$	~ 8.5	~ 13.0
BC1	10	65	71	2	0
BC2	8	45	41	0	0
BC3	8	67	68	3	1
BC4	9	73	51	<1	1
BC5	10	55	46	0	0
BC6	*	55	62	<1	4
BC7	2	57	47	0	0
BC8	**	60	60	0	0
BC9	**	59	55	0	0
10	16	60	44	0	0
11	**	59	55	0	0
12	*	*	60	4	3
13	**	65	*	*	*
14	10	44	63	0	3
15	*	*	65	<1	0

* No Data

** Peak Not Distinguishable

the related scans are included in Appendix C. Closely related concentrations were found for the entire survey area, as was first observed in the data presented in Table 5. Unfortunately, imagery was not available from infrared recording hardware as could be developed from the overflight for this survey. Thus, the laboratory infrared data and wet analyses results could only be compared with each other.

June 8, 1972 Survey

Parameters usually considered in field surveillance and monitoring of water quality for pollutants were lowest in orders of magnitude at the time of this survey than at any other time reported herein. Supersaturation of dissolved oxygen was also encountered at all fifteen Stations sampled. The locations of stations sampled during this survey are presented in Figure 30 and the physical,chemical, and biological data in Table 8. Imagery developed from KA62 hardware was obtained for analysis by I^2S instrumentation. Filters used on cameras 1, 2, and 3 during this overflight were different than those quoted in the Chapter on "Methodology". Specifications for the KA62 camera system are listed in Table 9.

Figure 30

Sample Sites; Mission 204; Site 256; 6-8-72

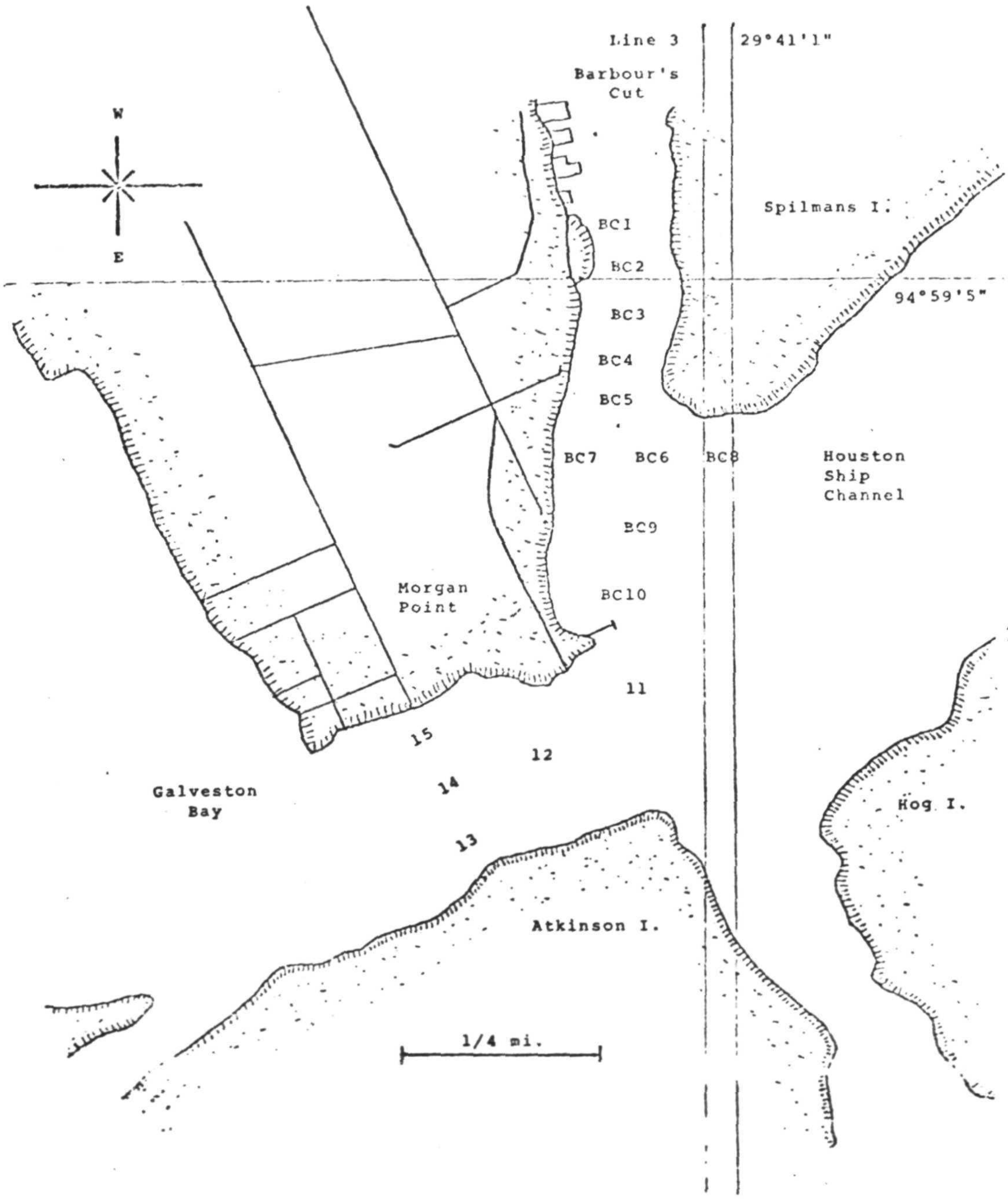


TABLE 8

Physical-Chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut. Sampling Date, June 8, 1972. Mission 204, Site 256.

Parameter	Station						
	BC1	BC2	BC3	BC4	BC5	BC6	BC7
pH	7.8	7.85	7.78	8.15	7.9	7.7	7.68
Dissolved Oxygen, mg/l	10.2	10.3	10.2	10.5	10.8	10.8	10.0
Dissolved Oxygen % Saturation	143	145	143	148	152	152	140
Temperature, °C;							
Surface	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Secchi Disc, in.	15.5	13.0	13.5	14.0	15.0	15.0	13.0
Turbidity J.T.U.	42	49	46	47	42	44	42
Specific Conductance, μmhos/cm x 10^4	1.62	1.44	1.97	1.65	1.76	1.85	1.90
Salinity, $^{\circ}/_{\circ\circ}$	15	15	15	15	15	15	15
Total Inorganic Carbon, mg/l	21	20	21	21	21	20	21
Total Organic Carbon, mg/l	11	11	9	10	9	9	9
Chemical Oxygen Demand, mg/l	36	42	32	< 10	28	35	32
Biochemical Oxygen Demand, mg/l	12	14	< 5	< 5	< 5	7	< 5
Chlorophyll-a, mg/l	0.114	0.114	0.114	0.107	0.111	0.122	0.068

TABLE 8 (Cont'd)

Physical-Chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut. Sampling Date, June 8, 1972. Mission 204, Site 256.

Parameter	Station							
	BC8	BC9	BC10	11	12	13	14	15
pH	7.5	8.18	8.21	8.15	8.05	8.2	8.0	8.2
Dissolved Oxygen, mg/l	10.2	10.4	10.0	9.0	7.9	9.8	7.8	10.2
Dissolved Oxygen & Saturation	143	146	140	127	111	138	110	143
Temperature, °C;								
Surface	28.0	28.0	28.0	28.3	28.0	28.2	28.0	28.5
Secchi Disc, in.	14.0	14.0	14.0	14.0	16.0	15.5	15.5	14.0
Turbidity J.T.U.	43	45	44	47	40	47	40	48
Specific Conductance, µmhos/cm x 10^4	1.75	2.03	1.87	2.06	2.18	2.18	2.2	1.96
Salinity, °/₀₀	15.5	16	16	16	16	16	16	16
Total Inorganic Carbon, mg/l	22	21	21	22	23	21	21	21
Total Organic Carbon, mg/l	8	9	9	8	5	8	8	8
Chemical Oxygen Demand, mg/l	51	48	64	61	66	64	59	67
Biochemical Oxygen Demand, mg/l	8	7	14	11	13	9	11	17
Chlorophyll-a, mg/l	0.111	0.218	0.093	0.100	0.076	0.193	0.125	0.179

TABLE 9

Data Relative To I^2S Analysis Of KA62 Prints*:
Mission 204, Site 256; June 8, 1972 Survey

Camera No.	Film	Roll And Position	Filter	Bandwidth
1	2402	3	23A	0.550-0.700μm
2	2402	4	47B	0.375-0.525μm
3	2402	5	57	0.480-0.590μm

* Relative to data shown in Figures 31-34 only

Identical frames were taken from each of the three KA62 cameras under consideration. Subsequently, each of the three was analyzed in the I^2S Viewer. That frame taken from camera #1, which used the red filter, demonstrated the highest degree of clarity, resolution and contrast. That frame was then analyzed by imposing the color code shown in Figure 31. Application of the digital red band resulted in the product shown in Figure 32. The color scheme demonstrated in that Figure most closely resembles the data presented in Table 8 for the chemical oxygen demand concentrations. The digital green band applied to the same image resulted, with some alteration in coding, in the scheme presented in Figure 33. Some loss of resolution between film densities is seen when comparing the water areas between Figure 32 and Figure 33. The digital green band would permit greater resolution of watercraft wakes as can be seen by the wake shown for the barges and tug proceeding up the Channel (from lower left to upper right in the print). Application of the digital blue band (Figure 34) demonstrated a marked loss of resolution. Virtually no meaningful interpretation would be forthcoming from that imagery.

Corresponding laboratory infrared analyses were conducted on the water samples taken during this survey. The IR Scans are presented in Appendix D and summary absorption

band values presented in Table 10. Relative to the observations presented for the physical, chemical, and biological data (Table 8), marked similarities are evident between the data presented for the absorbance values quoted in Table 10 for the 3.4μ band and the carbonaceous content, turbidity, and penetrability values for the waters in the survey site.

Comparisons of the digital red band application of I^2S densities to the film and the values obtained for all fifteen stations sampled for organic carbon, turbidity, C.O.D., penetrability, and chlorophyll by linear regression analysis are presented in Figures 35 through 39, a summary of the correlation coefficients developed therefrom are as follows:

Parameter	r	Figure No.
Organic Carbon	+0.189	35
Turbidity	-0.119	36
C.O.D.	-0.300	37
Secchi Disc	-0.036	38
Chlorophyll	-0.236	39

Although the value shown for C.O.D. correlation with density represents the highest correlation between parameters, the values were not as significant as those obtained, and summarized earlier, for the February investigation. This was due, in part, to the close relationship between concentrations for all pollution parameters measured in the test site waters at the time of the survey.

FIGURE 31

COLOR CODE FOR I^2S PRINTS - FIGURES 32, 33, AND 34
NASA S-72-49477

RELATIVE DENSITY INCREASES FROM LOW (LIGHT BLUE) TO HIGH (GREEN) AT CONSTANT INCREMENTS

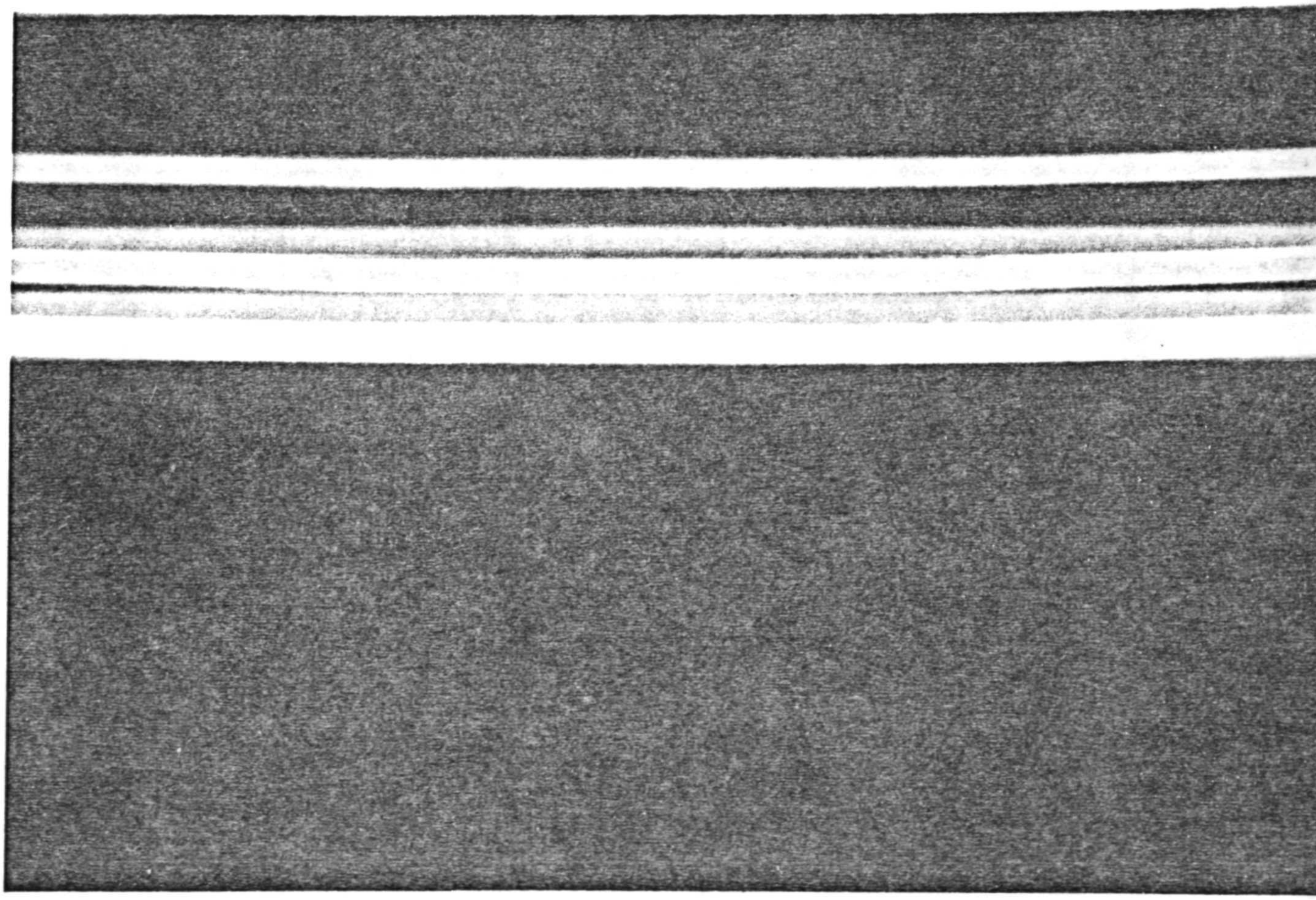


FIGURE 32

PRINT FROM I^2S FILM ANALYSIS:
DIGITAL RED BAND APPLIED
NASA S-72-49479
DATE: JUNE 8, 1972
MISSION 204, SITE 256
CAMERA: KA62 #1 POSITION #3
FILM TYPE: 2402
FILTER: 23A
FRAME 05-0020

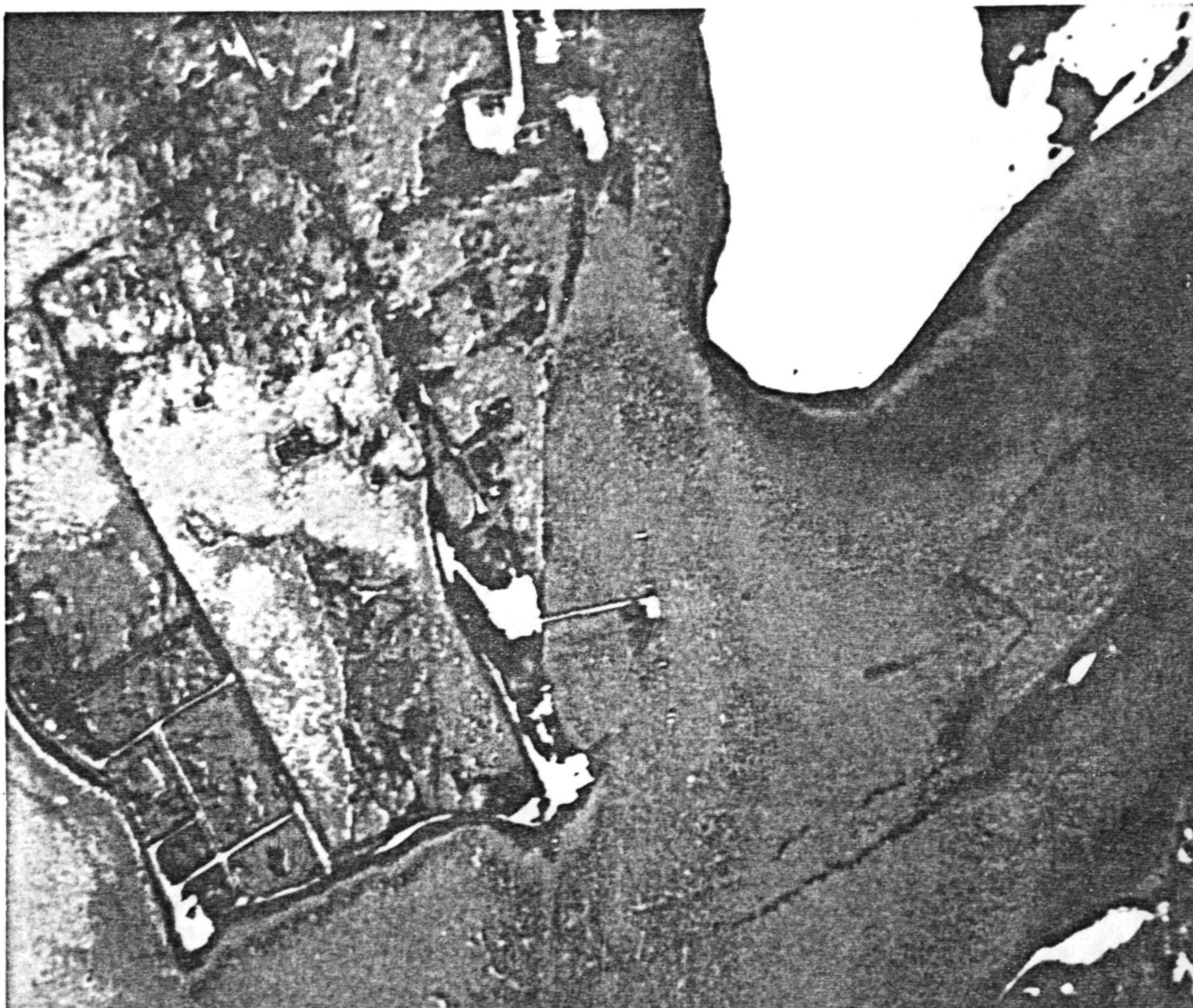


FIGURE 33

PRINT FROM I^2S FILM ANALYSIS:
DIGITAL GREEN BAND APPLIED
NASA S-72-49476
DATE: JUNE 8, 1972
MISSION 204, SITE 256
CAMERA: KA62 #2 POSITION #4
FILM TYPE: 2402
FILTER: 47B
FRAME: 05-0020

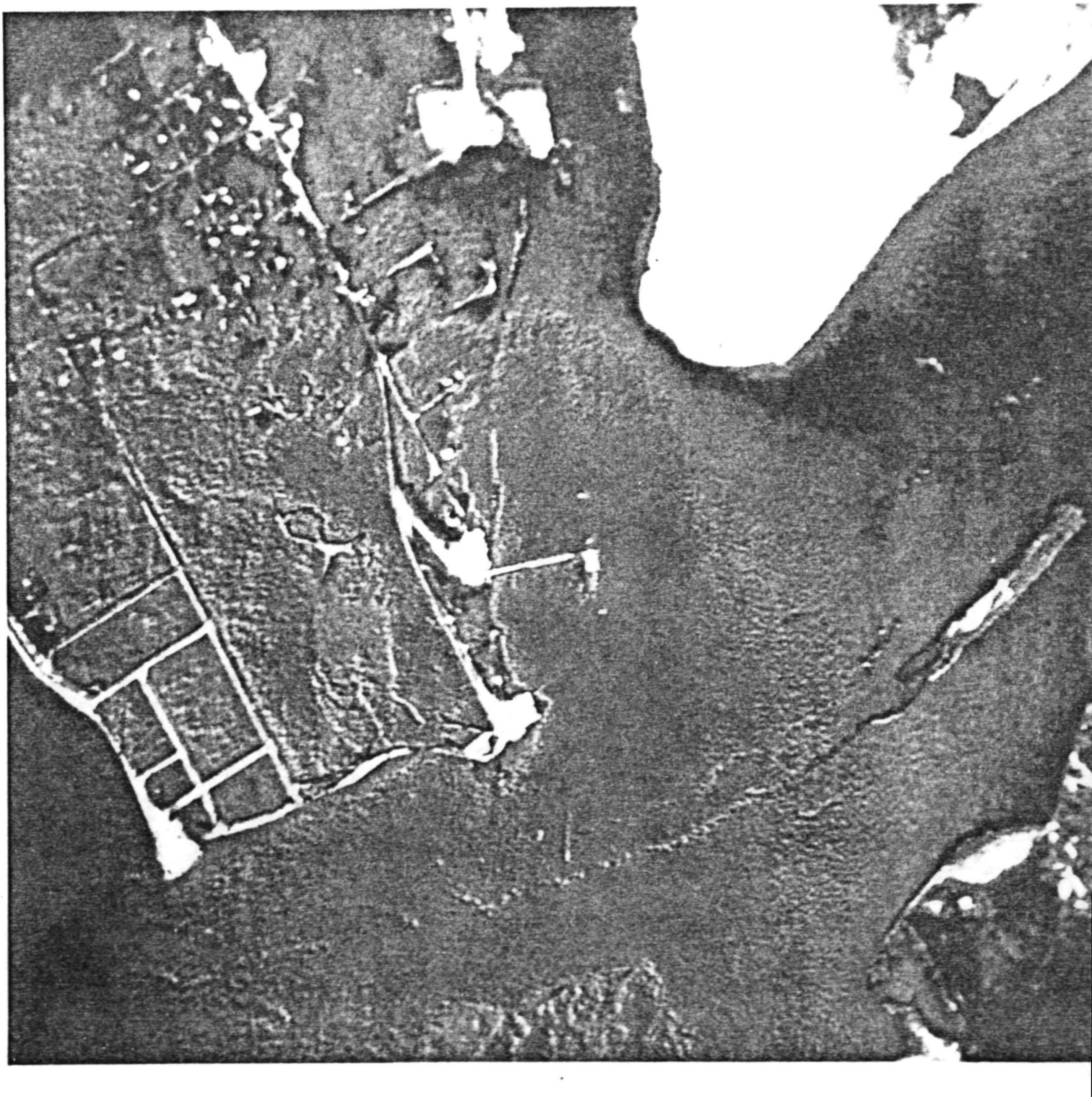


FIGURE 34

PRINT FROM I^2S FILM ANALYSIS:
DIGITAL BLUE BAND APPLIED
NASA S-72-49478
DATE: JUNE 8, 1972
MISSION 204, SITE 256
CAMERA: KA62 #3 POSITION #5
FILM TYPE: 2402
FILTER: 57
FRAME: 05-0020

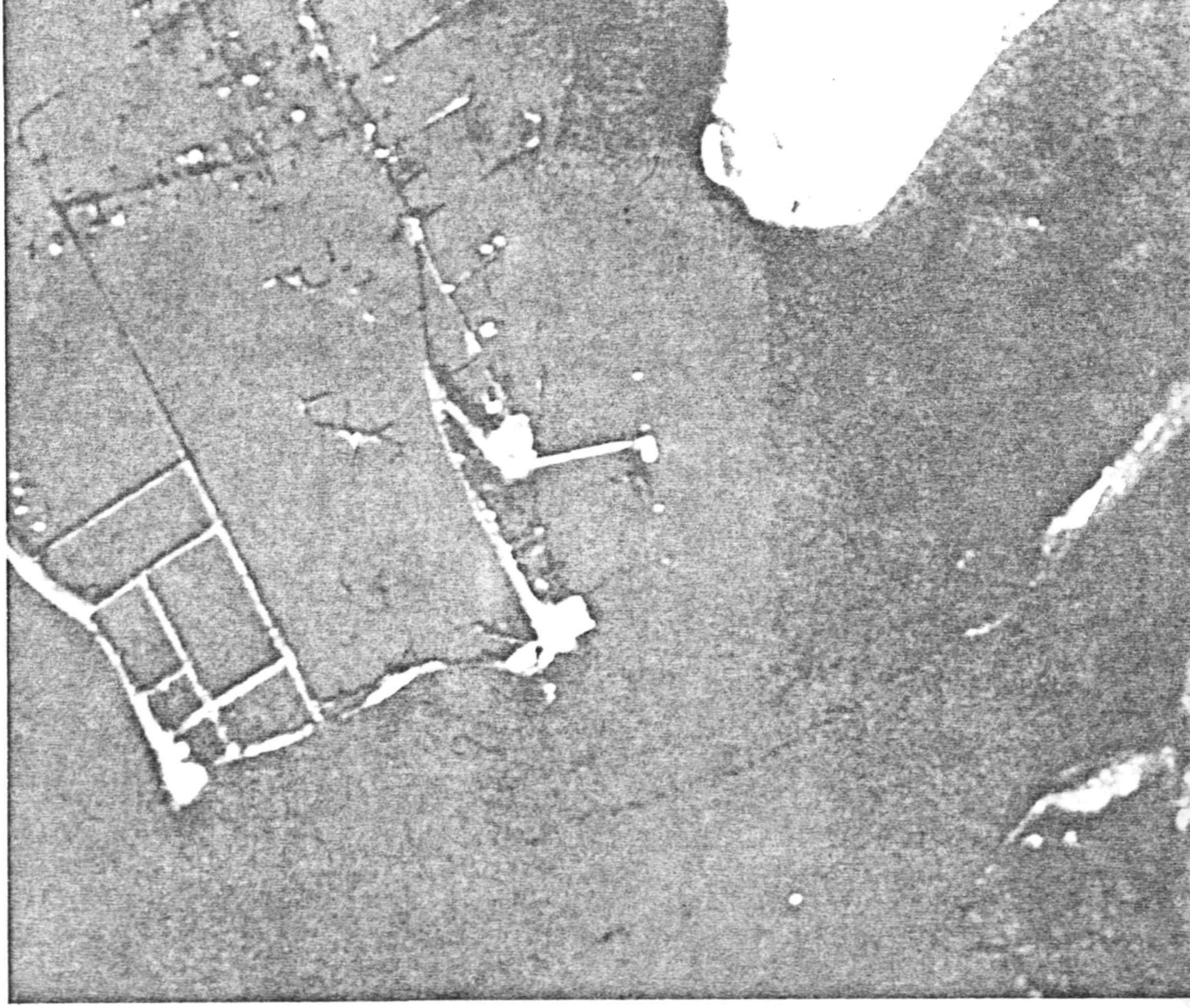


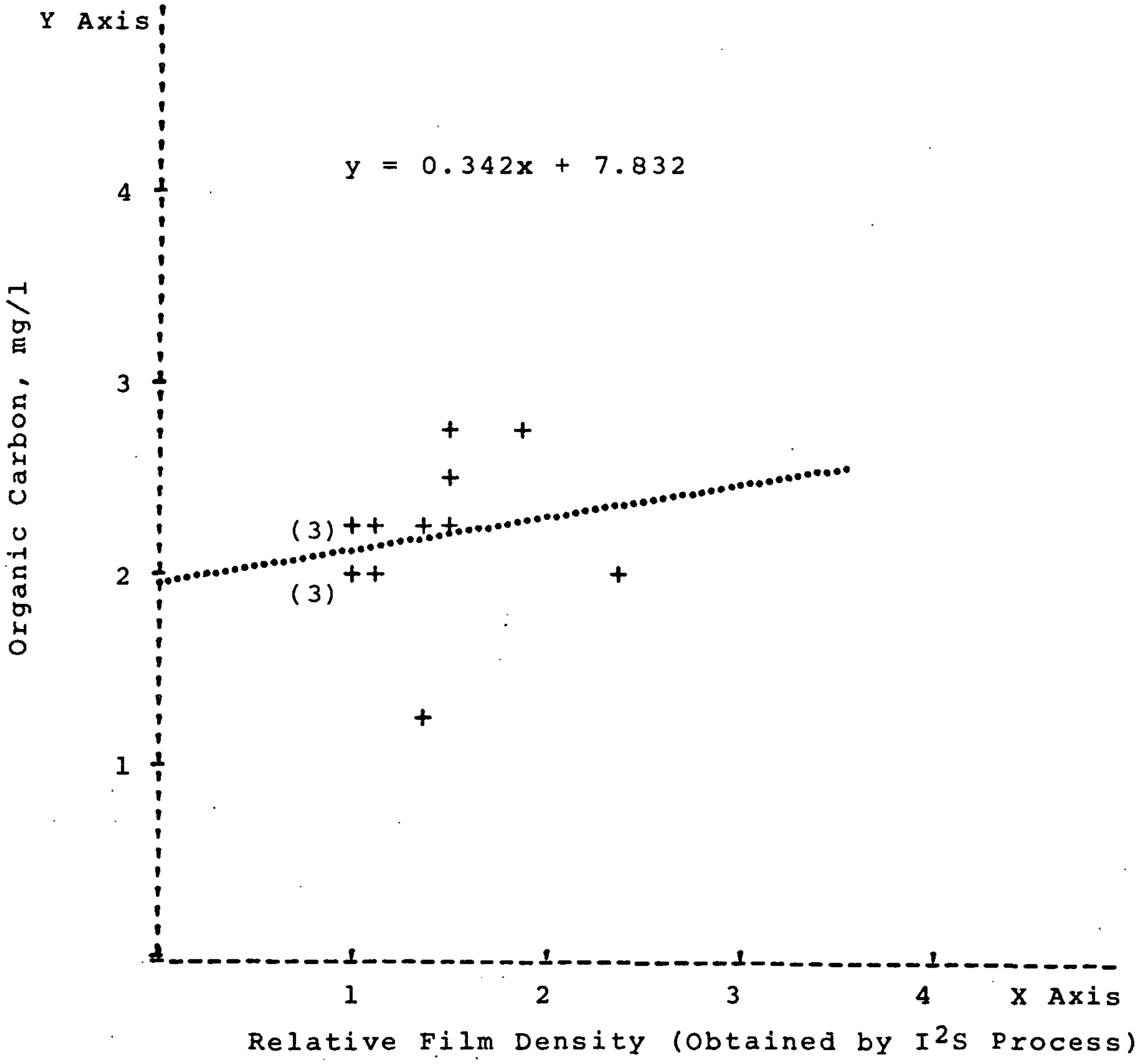
TABLE 10

Absorption Values For Three IR Spectrophotometric Analysis Techniques; June 8, 1972 Survey

Station	Reflectance ATR $\sim 5.3\mu$	CCl_4 Extract $\sim 3.4\mu$	KBr Evaporate ~ 3.4	~ 8.5	~ 13
BC1	0	19	28	0	2
BC2	0	32	30	0	3
BC3	0	23	39	0	0
BC4	0	44	45	0	3
BC5	0	33	53	0	2
BC6	0	39	36	0	3
BC7	0	55	37	0	5
BC8	0	41	20	0	0
BC9	0	31	23	0	12
BC10	0	38	43	0	5
11	0	50	51	0	2
12	0	29	27	0	0
13	0	41	25	0	9
14	0	52	9	0	2
15	0	25	45	0	13

FIGURE 35

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and organic carbon content of field samples collected on June 8, 1972



$a(0) = 7.832$ $r = .189$

$\hat{a}(1) = .342$ $S(y.x) = 1.364$

One X Axis unit = 2.00 $n = 15$

One Y Axis unit = 4.00

Data Points Represented = BC1 through BC10, and 11 through 15.

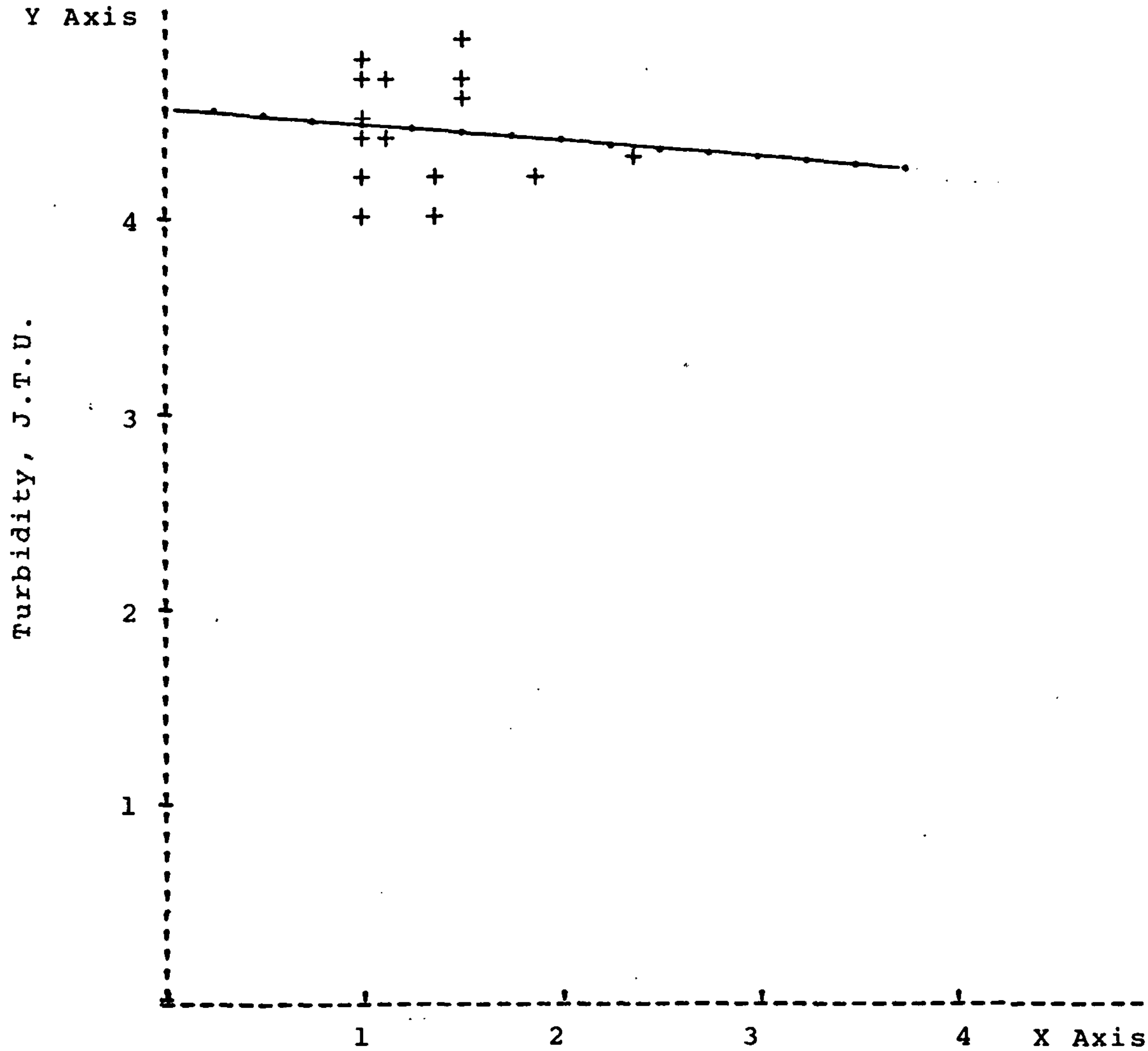
Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 36

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 Black-and-White image and turbidity values from field samples collected on June 8, 1972



Relative Film Density (Obtained by I^2S Process)

a(0) = 45.530 r = -.119

$\hat{a}(1)$ = -.429 S(y.x) = 2.756

One X Axis unit = 2.00 n = 15

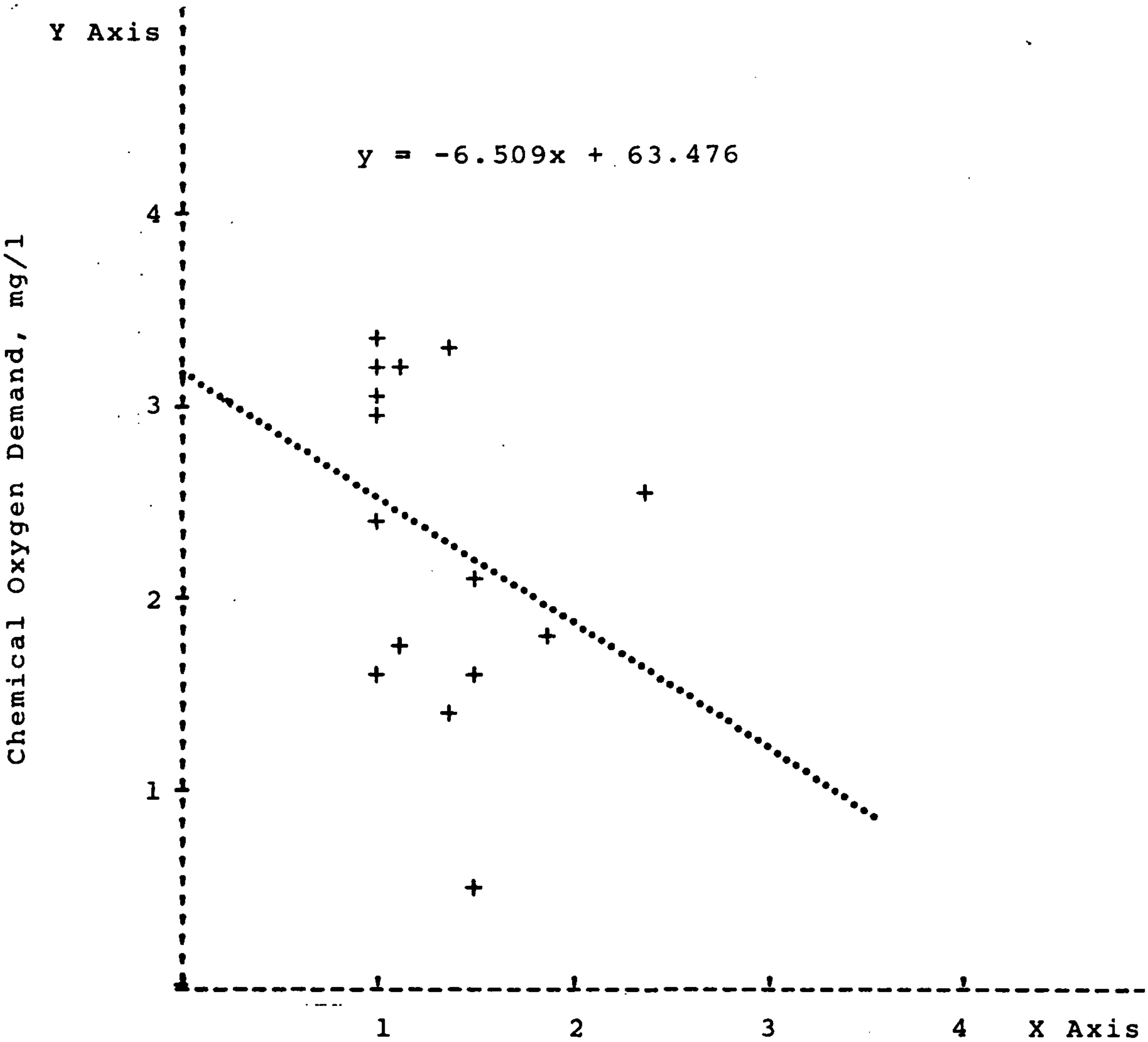
One Y Axis unit = 10.00

Data Points Represented = BC1 through BC10, and 11 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 37

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and chemical oxygen demand values from field samples collected on June 8, 1972



Relative Film Density (Obtained by I^2S Process)

a(0) = 63.476 r = -.300

â(1) = -6.509 S(y.x) = 15.883

One X Axis unit = 2.00 n = 15

One Y Axis unit = 20.00

Data Points Represented = BC1 through BC10, and 11 through 15.

Conclusion About Hypothesis, â(1) = 0; Not Rejected

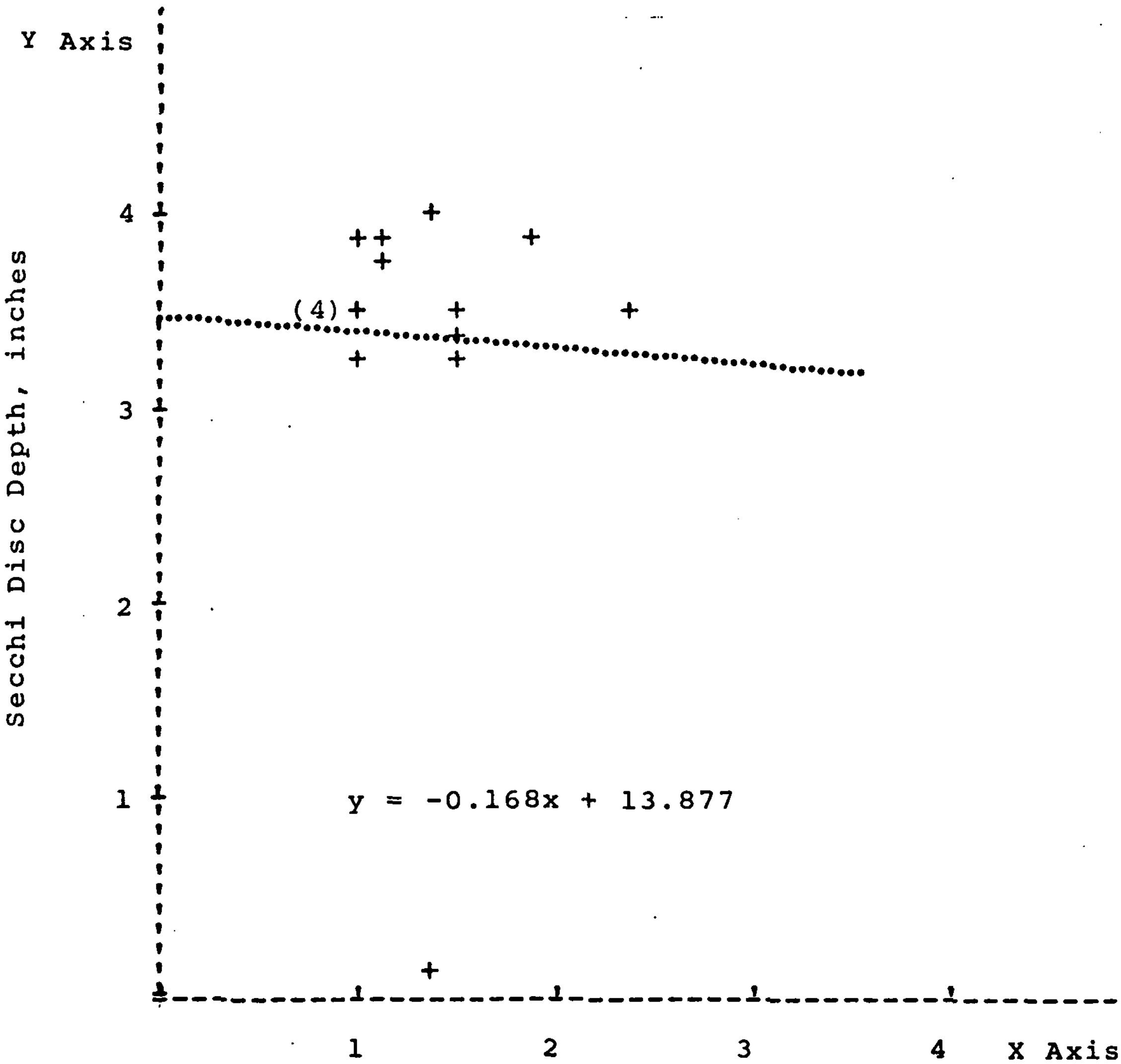
2 of 2

FIGURE 38

Linear Regression Analysis

$y = a(0) + a(1)x$

Correlation between relative film densities from KA62 *Black-and-White image* and Secchi Disc readings from field samples collected on June 8, 1972



Relative Film Density (Obtained by I^2S Process)

$a(0) = 13.877$ $r = -.036$

$\hat{a}(1) = -.168$ $S(y.x) = 3.57$

One X Axis unit = 2.00 $n = 15$

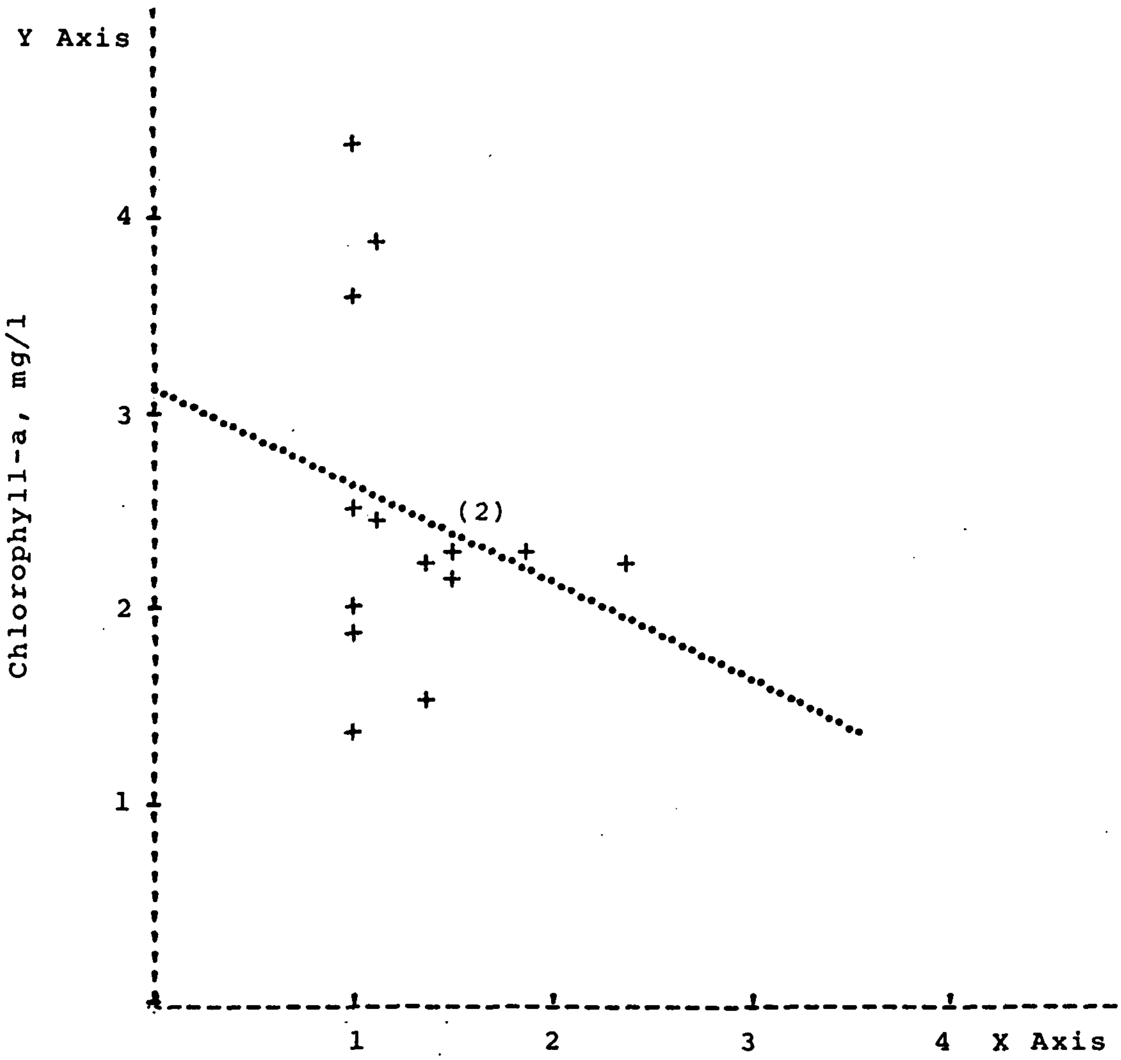
One Y Axis unit = 4.00

Data Points Represented = BC1 through BC10, and 11 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

FIGURE 39

Linear Regression Analysis
$y = a(0) + a(1)x$
Correlation between relative film densities from KA62 Black-and-White image and chlorophyll-a values from field samples collected on June 8, 1972



Relative Film Density (Obtained by I^2S Process)

$a(0) = .156$ $r = -.236$

$\hat{a}(1) = -.012$ $S(y.x) = .039$

One X Axis unit = 2.00 $n = 15$

One Y Axis unit = .050

Data Points Represented = BC1 through BC10, and 11 through 15.

Conclusion About Hypothesis, $\hat{a}(1) = 0$; Not Rejected

Imagery which was available for analysis in the 8-14μ bandwidth was limited to one frame of the test area from Channel 2 of the RS-14 from the October 7, 1971 survey. Isodensitracer analysis was applied to a small segment of the frame. For purposes of direction to the specific tasks and mission of the total investigation, reference is made to Figure 6 and Table 3 which contain, respectively, the Isodensitracer image and color coding data. For reason or reasons unknown, the operator chose to limit the boundary of the Isodensitracer recording to approximately half the distance of the Houston Ship Channel, thereby eliminating the region in which stations 1 and 2 were surveyed. Therefore three data points remain (Stations 3, 4, and 5) for analysis. Fortunately, some meaningful interpretation can be derived from these points. For this purpose, Table 11 is included as a summary of prior data which applies specifically to the area covered by the imagery in question. Statistical analysis, such as regression analyses, would be meaningless, if applied to the three data points. Noting, however, the trends in Table 11, and the interpretation of film density at stations 3 through 5, some strong cases can be suggested for correlation. Station 5 yields, generally, the lowest of the three densities, and assuming the green coded data to proceed through station 3, as would have

occurred had the frame been completed, the following interpretations are evident by casual observation alone. Absorption in the 5.3μ band, 3.4μ band and turbidity showed some increase with density increases. Total carbon content, C.O.D., KBr evaporate at the 3.4μ band, and dissolved oxygen concentration all exhibited what may have been an inverse relationship with imagery densities. These, of course, are not conclusive but strongly suggest a relationship between measurable pollution parameters and imagery densities in comparable waveband regions.

Table 11. Summary Data For Correlation of Isodensitracer Film Detection Capability and Selected Water Quality Factors; October 7, 1971 Survey

Parameter	Site		
Isodensitracer Code (1)	5 red (—) (21-24)	4 red (.) (26-29)	3 green (..) (31-34)
Infrared Analysis:			
Reflectance (5.3μ) (2)	3	5	8
CCl_4 Extract (3.4μ) (2)	30	47	34
KBr Evaporate (3.4μ) (2)	--	43	33
KBr Evaporate (8.5μ) (2)	--	--	0
KBr Evaporate (13μ) (2)	--	26	0
Total Carbon, mg/l (3)	44	43	41
Organic Carbon, mg/l (3)	22	20	20
Inorganic Carbon, mg/l (3)	22	23	21
Turbidity, J.T.U. (3)	42	41	45
C.O.D., mg/l (3)	180	155	127
Secchi Disc, ft. (3)	1.5	1.5	1.5
Dissolved Oxygen, mg/l (3)	3.8	3.7	3.5

(1) Ref. Figure 6 and Table 3
(2) Ref. Table 4
(3) Ref. Table 2

DERIVATIONS

This investigation proceeded with the unalterable intention of providing the most reliable, comprehensive, and accurate ground truth assessment of a reach of the Houston Ship Channel and an adjacent backwater, Barbour's Cut. Remote sensing imagery developed from concurrent overflights of that area were analyzed for comparison and correlation of ground truth and film density data by use of instrumentation developed for that specific purpose. Although specific conclusions are included in the text the following additional conclusions have become evident through the course of the investigation.

1. Although permanent records are available of an area following the development of overflight imagery, rapid assessment of the imagery will necessarily have to be enhanced to offer competition to the existing methods of pollution assessment by wet analytical laboratory methodology.
2. Color and Color-Infrared prints can aid in locating areas for more sophisticated hardware interpretation implementation.

3. Considerable promise is indicated by correlation of Channel 2, RS-14 imagery (8-14μ bandwidth) laboratory IR spectrophotometric scans, and Isodensitracer interpretation of black-and-white transparencies.
4. Hardware used for image density interpretation included the Datacolor Machine, Isodensitracer, and I^2S film viewer. Of these, the Datacolor film interpretation data offered a numerically greater correlation than the I^2S hardware. Film type 2402, of the KA62 camera system, black-and-white transparencies were employed for both analyses. Isodensitracer analysis, on the other hand, provided, in the majority of cases, numerically lower correlation coefficients than did the Datacolor interpretation.
5. Isodensitracer application to 8-14μ black-and-white transparency density analysis appears to offer promise as an effective organic carbon analysis tool when correlated with infrared spectrophotometric absorption peaks of functional carbonaceous materials as well as conventional pollution factor wet laboratory analyses.

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APPENDIX A

LOCATION MAP; JANUARY 19, 1972 FIELD SURVEY

PHYSICAL, CHEMICAL, BIOLOGICAL DATA;

JANUARY 19, 1972 FIELD SURVEY

Figure A-1

Sample Sites; 1-19-72 No NP3A Flight this date

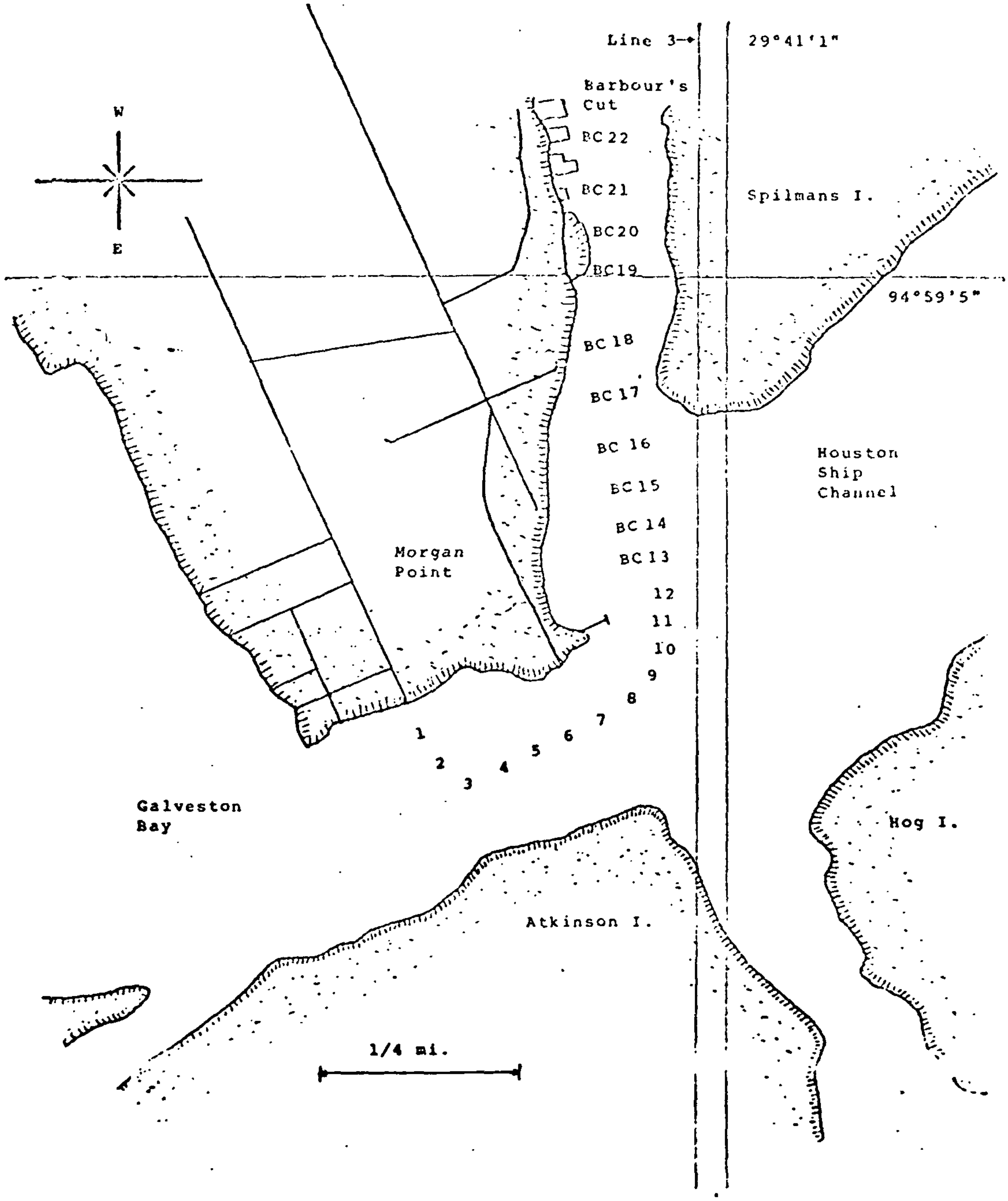

TABLE A-1

Physical-chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut Test Site 256. Sampling Date, January 19, 1972.

Parameter	Station							
	1	2	3	4	5	6	7	8
pH	8.4	8.4	8.5	8.5	8.4	8.4	---	8.3
Dissolved Oxygen, mg/l	10.0	11.0	10.2	10.1	10.7	10.9	---	11.2
Dissolved Oxygen % Saturation	104	113	105	104	110	112	---	115
Temperature, °C;								
Surface	12.5	12.0	12.0	12.0	12.0	12.0	---	12.0
Secchi Disc, in.	13.0	13.0	13.0	13.0	13.0	13.0	---	13.0
Turbidity J.T.U.	28	33	38	33	42	39	---	40
Specific Conductance, µmhos/cm x 10^4	1.24	1.32	1.42	1.50	1.50	1.45	---	1.48
Salinity, °/₀₀	9	9	9	10	10	10	---	10
Total Inorganic Carbon, mg/l	21	22	21	23	21	21	---	21
Total Organic Carbon, mg/l	30	22	19	24	24	23	--	24
Chemical Oxygen Demand, mg/l	79	51	38	51	38	60	---	36
Alkalinity, mg/l								
P	10.2	8.1	10.2	16.2	8.2	4.1	---	10.2
T	111.6	109.6	113.7	111.6	109.9	109.6	---	105.6
Chlorophyll-a, mg/l	0.050	0.085	0.143	0.057	0.075	0.168	---	0.118

TABLE A-1 (Cont'd)

Physical-chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut
Test Site 256. Sampling Date, January 19, 1972.

Parameter	Station						
	9	10	11	12	BC13	BC14	BC15
pH	8.6	8.7	8.6	8.6	8.7	8.6	8.5
Dissolved Oxygen, mg/l	9.8	9.5	9.85	9.9	9.45	10.0	10.3
Dissolved Oxygen % Saturation	101	98	102	103	98	104	107
Temperature, °C;							
Surface	12.0	12.0	12.0	12.5	12.5	12.5	12.5
Secchi Disc, in.	13.0	13.0	12.5	12.5	12.3	12.0	12.0
Turbidity J.T.U.	36	40	36	42	37	40	36
Specific Conductance, μmhos/cm x 10^4	1.50	1.46	1.50	1.45	1.20	1.41	1.32
Salinity, °/oo	10	10	10	10	10	10	10
Total Inorganic Carbon, mg/l	21	22	21	22	21	21	21
Total Organic Carbon, mg/l	24	23	23	27	27	33	24
Chemical Oxygen Demand, mg/l	76	71	76	82	94	68	65
Alkalinity, mg/l							
P	8.1	8.1	8.1	8.1	10.2	8.1	6.1
T	115.7	115.7	113.7	113.7	113.7	113.7	113.7
Chlorophyll-a, mg/l	0.068	0.104	0.086	0.068	0.143	0.064	0.054

TABLE A-1 (Cont'd)

Physical-chemical Data for Samples Taken from Houston Ship Channel and Barbour's Cut Test Site 256. Sampling Date, January 19, 1972.

Parameter	Station						
	BC16	BC17	BC18	BC19	BC20	BC21	BC22
pH	8.6	8.7	8.5	8.6	8.5	8.7	8.7
Dissolved Oxygen, mg/l	10.1	9.6	10.4	10.2	10.3	9.6	9.55
Dissolved Oxygen % Saturation	105	100	108	106	107	100	99
Temperature, °C;							
Surface	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Secchi Disc, in.	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Turbidity J.T.U.	62	49	25	31	40	51	66
Specific Conductance, μmhos/cm x 10^4	1.42	1.44	1.38	1.30	1.35	1.36	1.35
Salinity, °/°°	10	10	9	9	9	9	9
Total Inorganic Carbon, mg/l	21	21	21	18	21	21	21
Total Organic Carbon, mg/l	27	30	24	19	24	28	31
Chemical Oxygen Demand, mg/l	60	76	75	68	64	76	60
Alkalinity, mg/l							
P	11.2	11.2	5.1	4.1	6.1	11.2	12.2
T	115.7	113.7	111.6	107.6	111.6	113.7	113.7
Chlorophyll-a, mg/l	0.086	0.097	0.054	0.125	0.061	0.214	0.272

APPENDIX B

IR SPECTROPHOTOMETRIC SCANS;

OCTOBER 7, 1971 FIELD SURVEY:

REFLECTANCE ATR(TR-9L)KRS-5

CCl_4 EXTRACT

KBr EVAPORATE

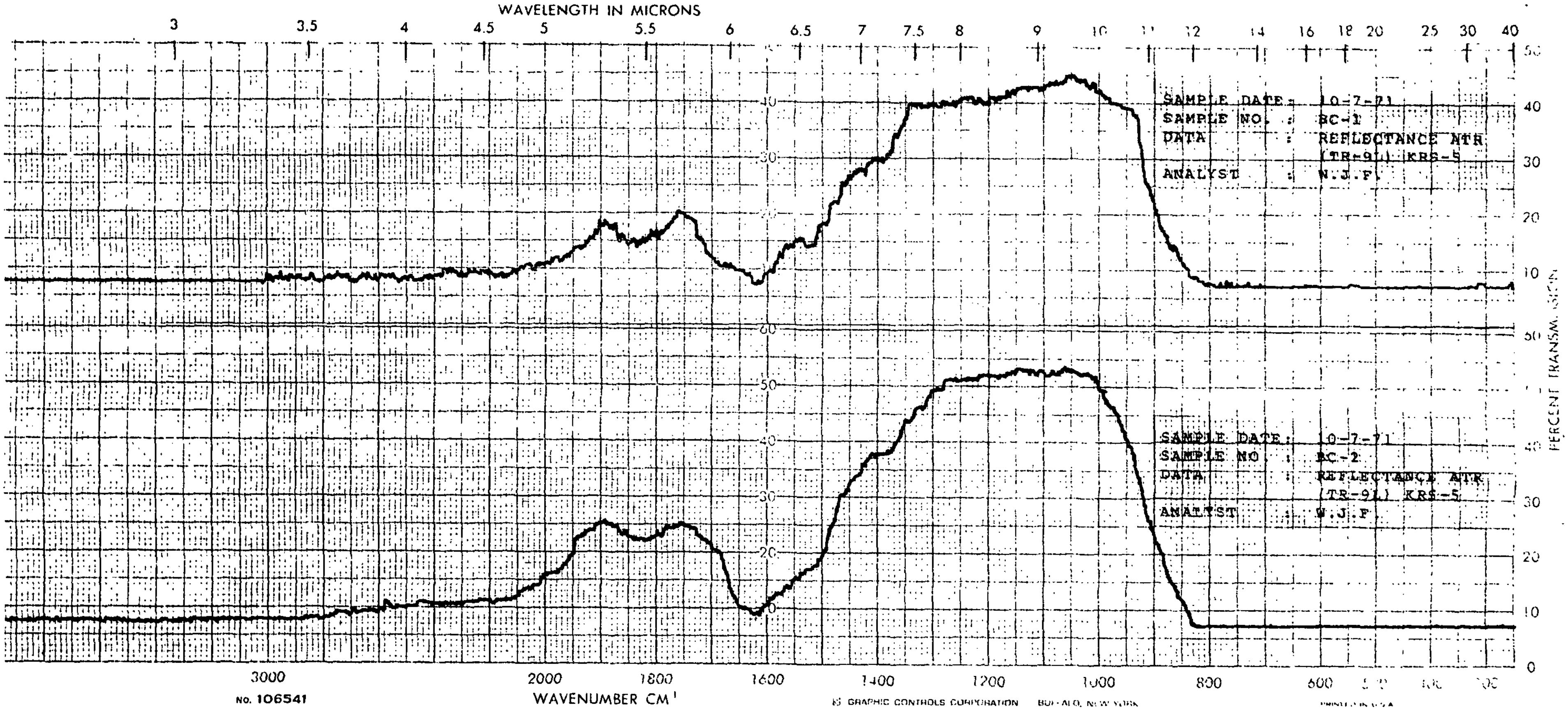
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE : 10-7-71
SAMPLE NO. : BC-1
DATA : REFLECTANCE ATR (TR-91) KRS-5
ANALYST : W.J.F.
SAMPLE DATE : 10-7-71
SAMPLE NO : BC-2
DATA : REFLECTANCE ATR (TR-91) KRS-5
ANALYST : W.J.F
PERCENT TRANSMISSION
3000 2000 1800 1600 1400 1200 1000 800 600
No. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK

Figure B-1

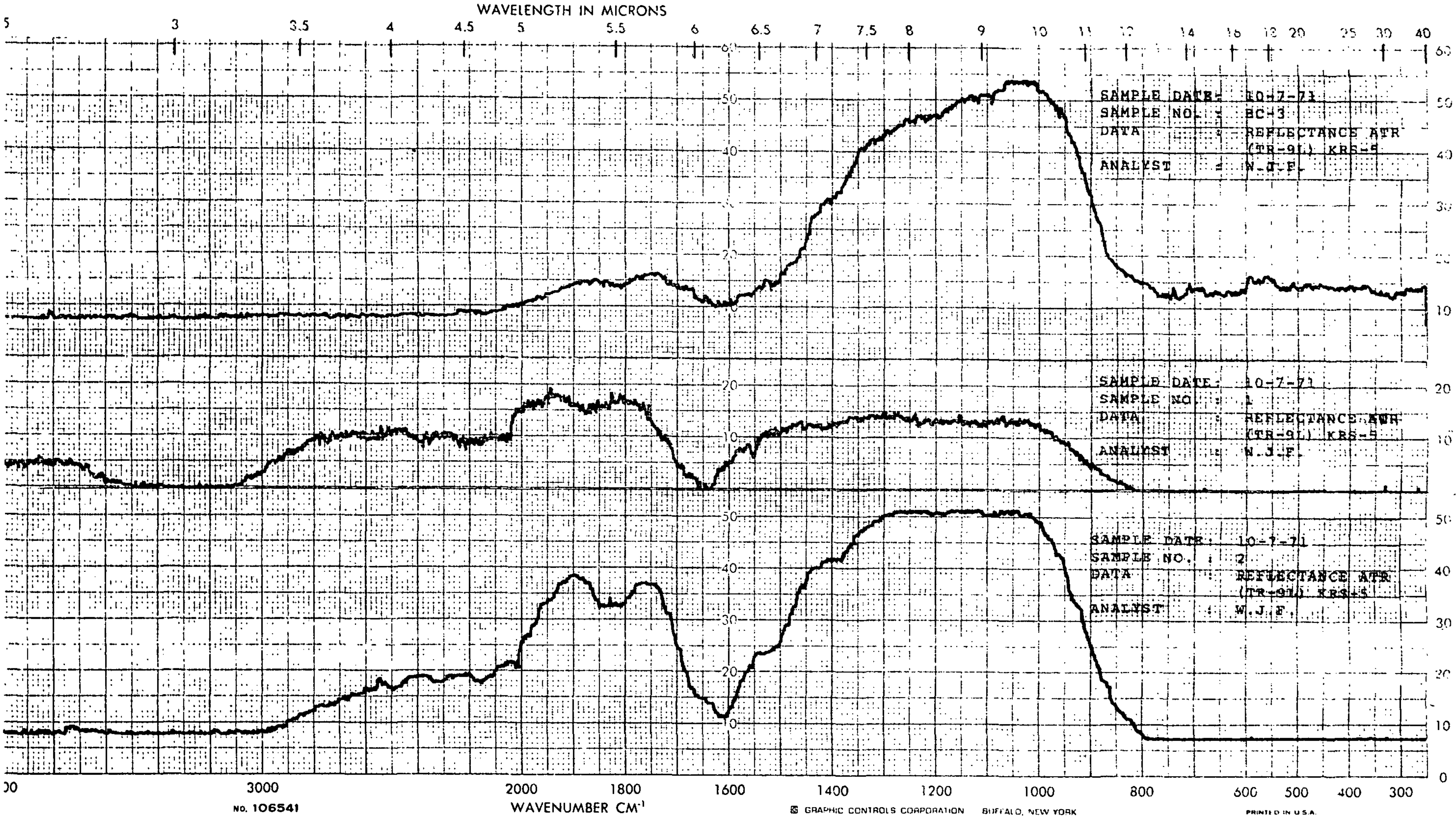
WAVELENGTH IN MICRONS
SAMPLE DATE : 10-7-71
SAMPLE NO. : BC-3
DATA : REFLECTANCE ATR (TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE : 10-7-71
SAMPLE NO. : 1
DATA : REFLECTANCE ATR (TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE : 10-7-71
SAMPLE NO. : 2
DATA : REFLECTANCE ATR (TR-9L) KRS-5
ANALYST : W.J.F.
WAVENUMBER CM⁻¹
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure B-2

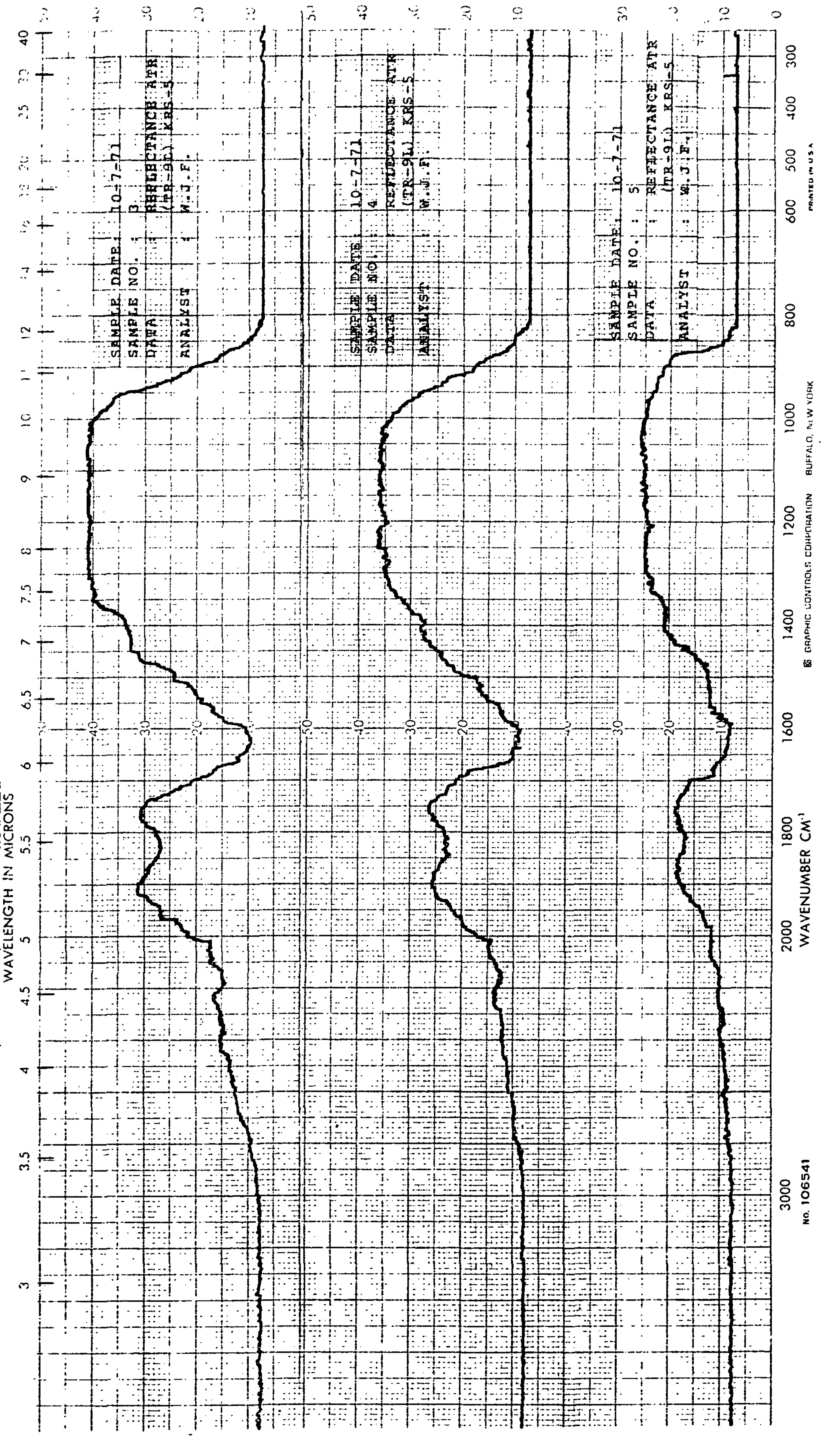
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 10-7-71
SAMPLE NO.: 3
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE NO.: 4
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE NO.: 5
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure B-3

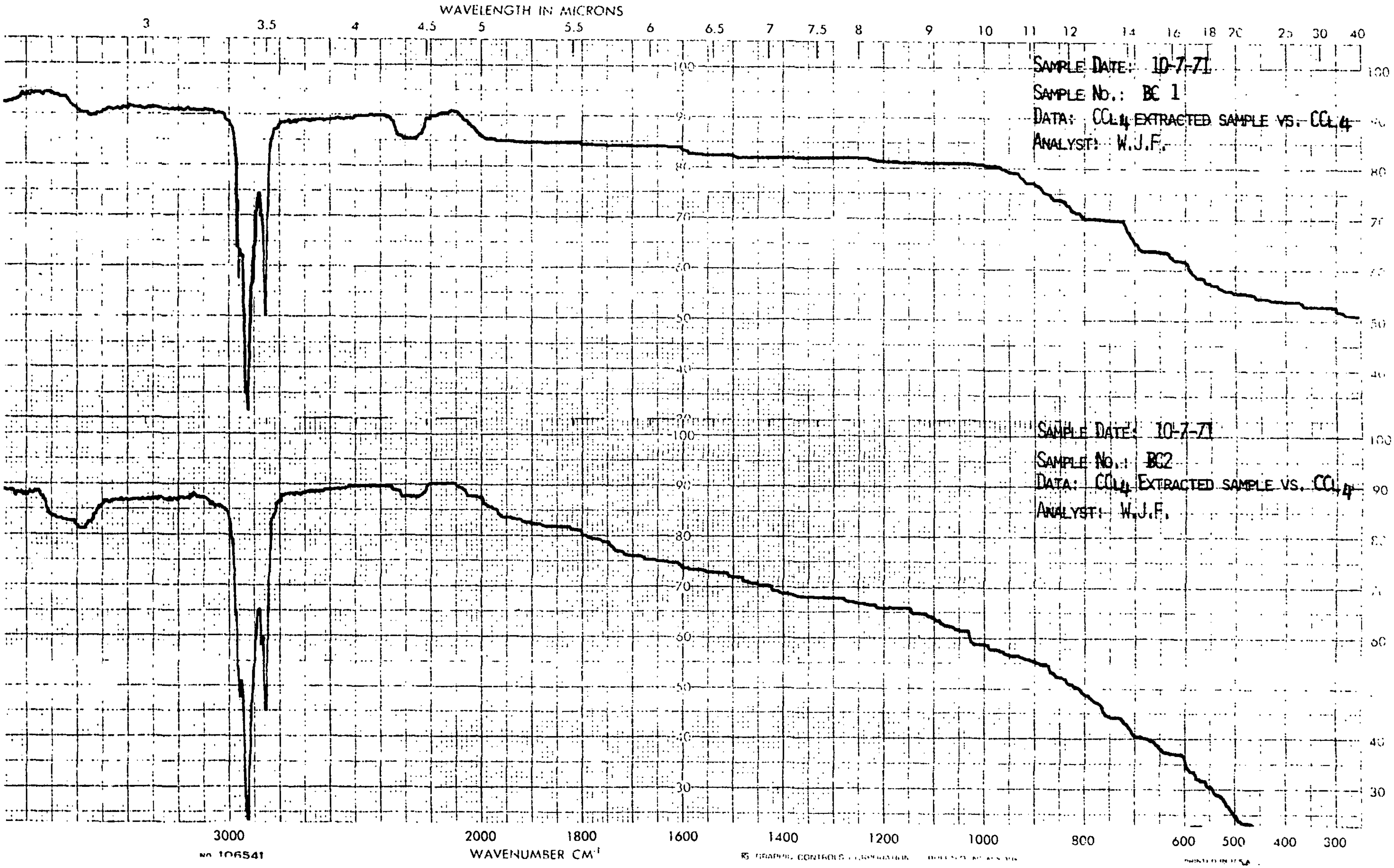
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 10-7-71
SAMPLE No.: BC 1
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE No.: BC2
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
No 106541

Figure B-4

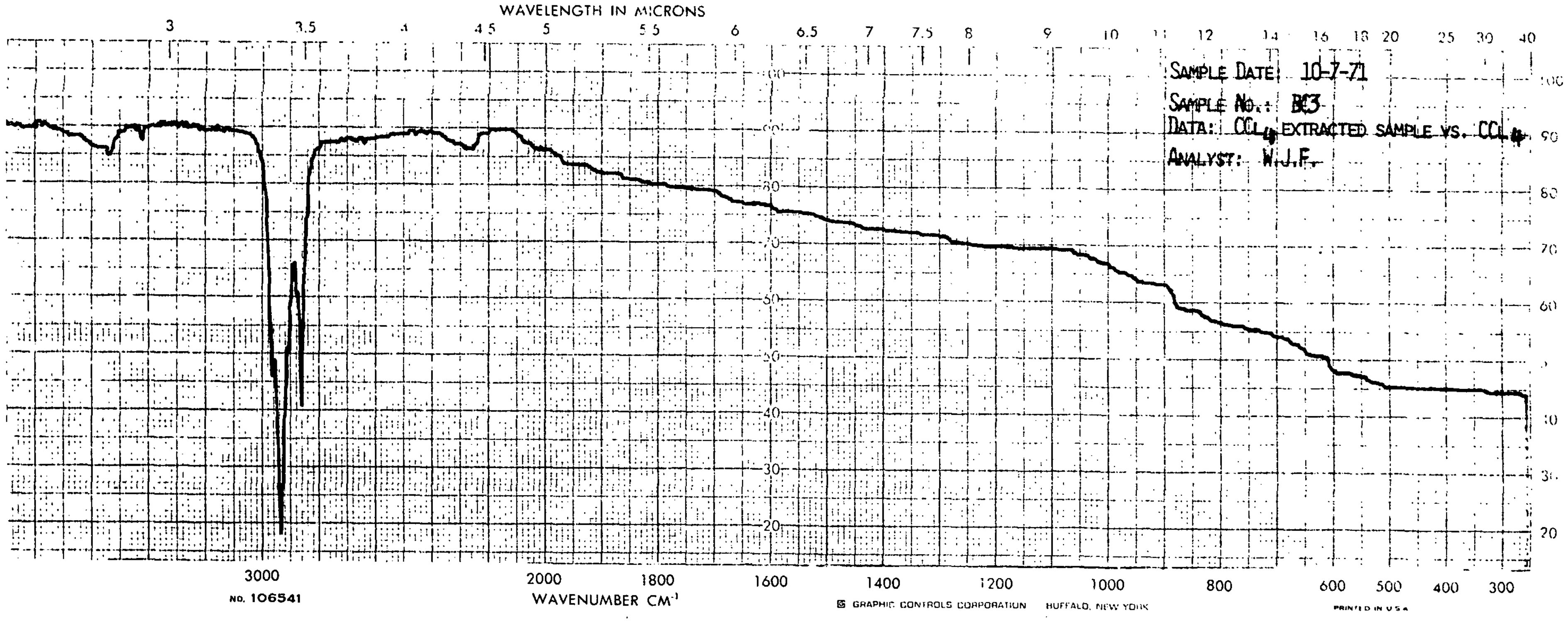
WAVELENGTH IN MICRONS
SAMPLE DATE: 10-7-71
SAMPLE No.: BC3
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
WAVENUMBER CM^{-1}
PERCENT TRANSMISSION
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure B-5

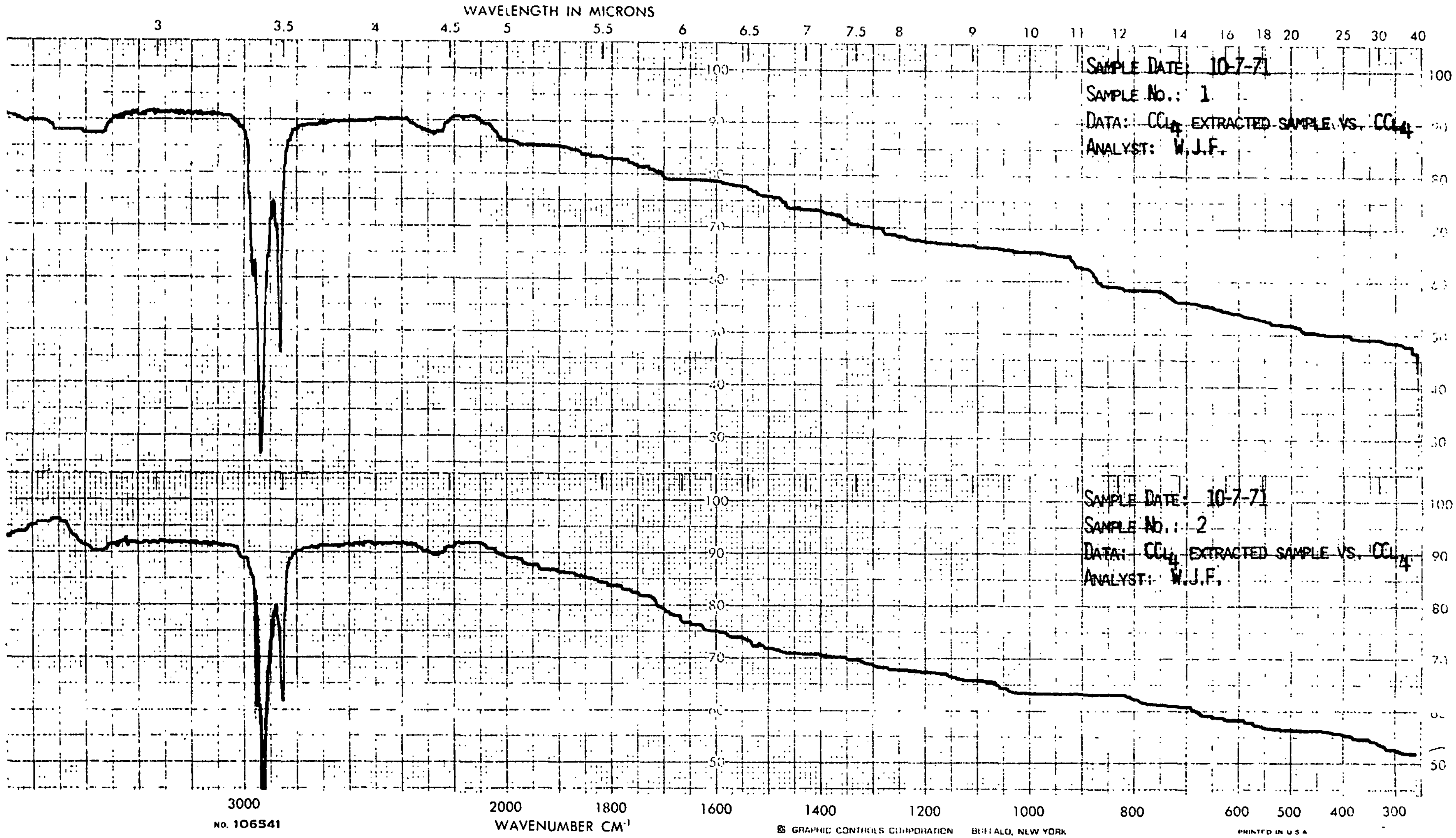
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 10-7-71
SAMPLE No.: 1
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE No.: 2
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK

Figure B-6

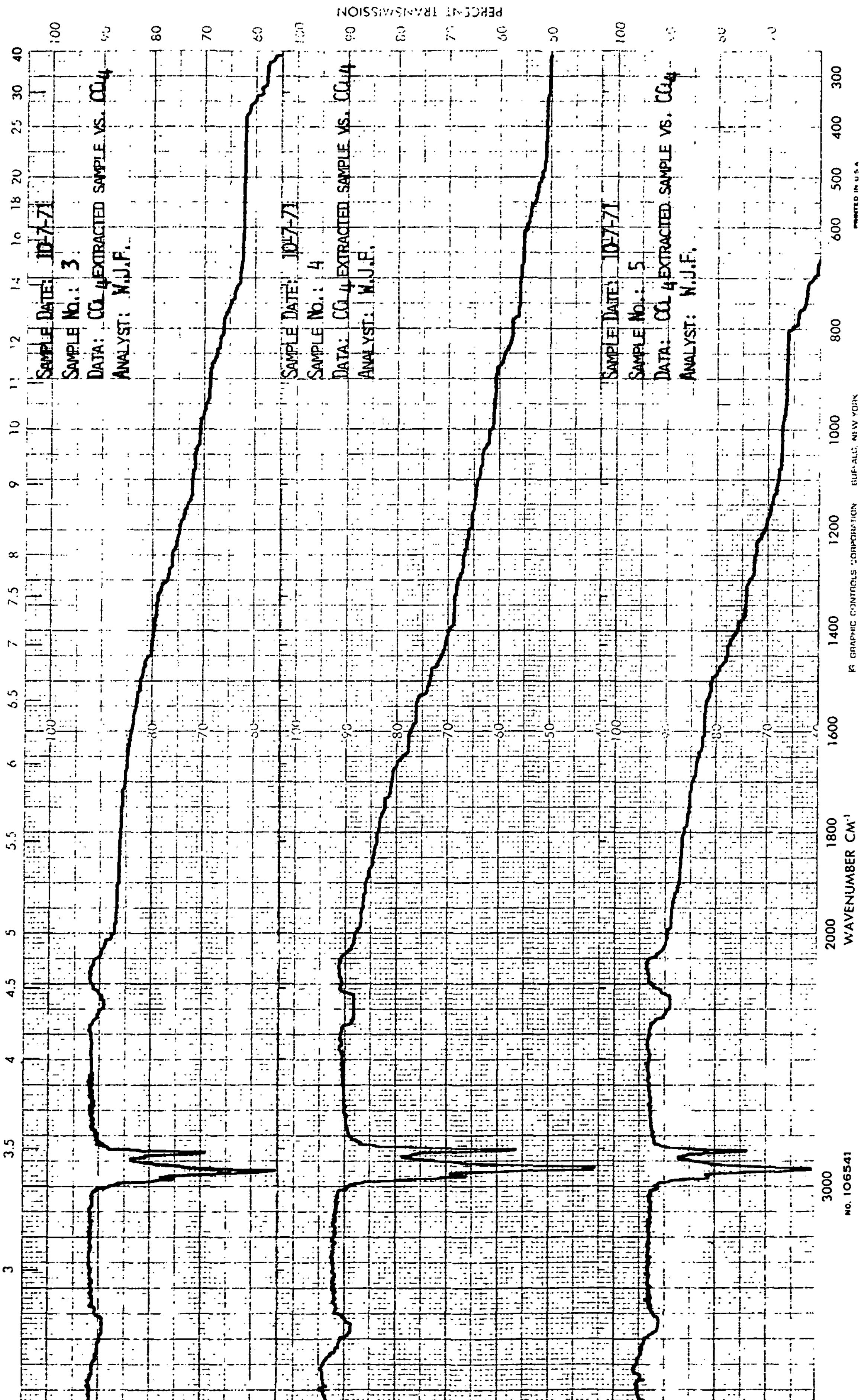
PERCENT TRANSMISSION
SAMPLE DATE: 10-7-71
SAMPLE No.: 3
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE No.: 4
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE No.: 5
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
WAVENUMBER CM-1
NO. 106541
IR GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure B-7

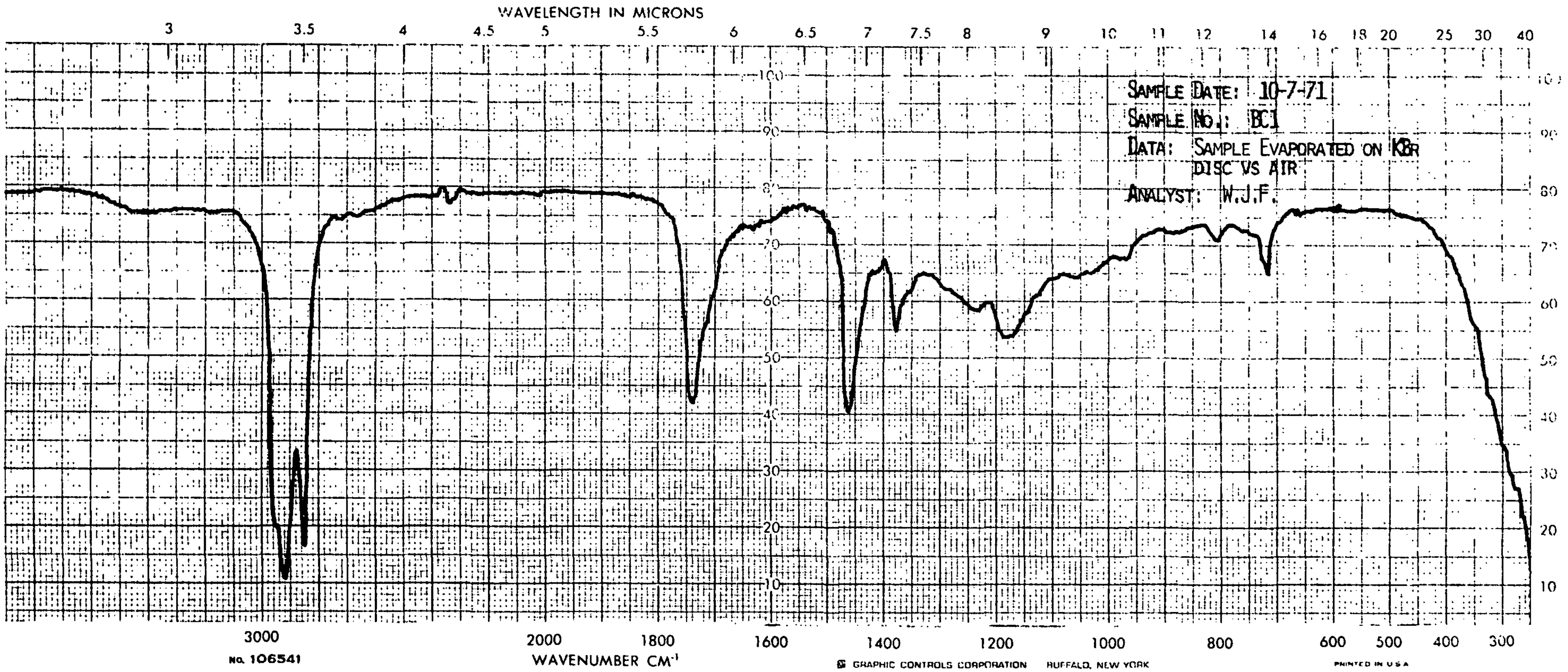
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 10-7-71
SAMPLE NO.: BC1
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40 30 20 10
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
No. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure B-8

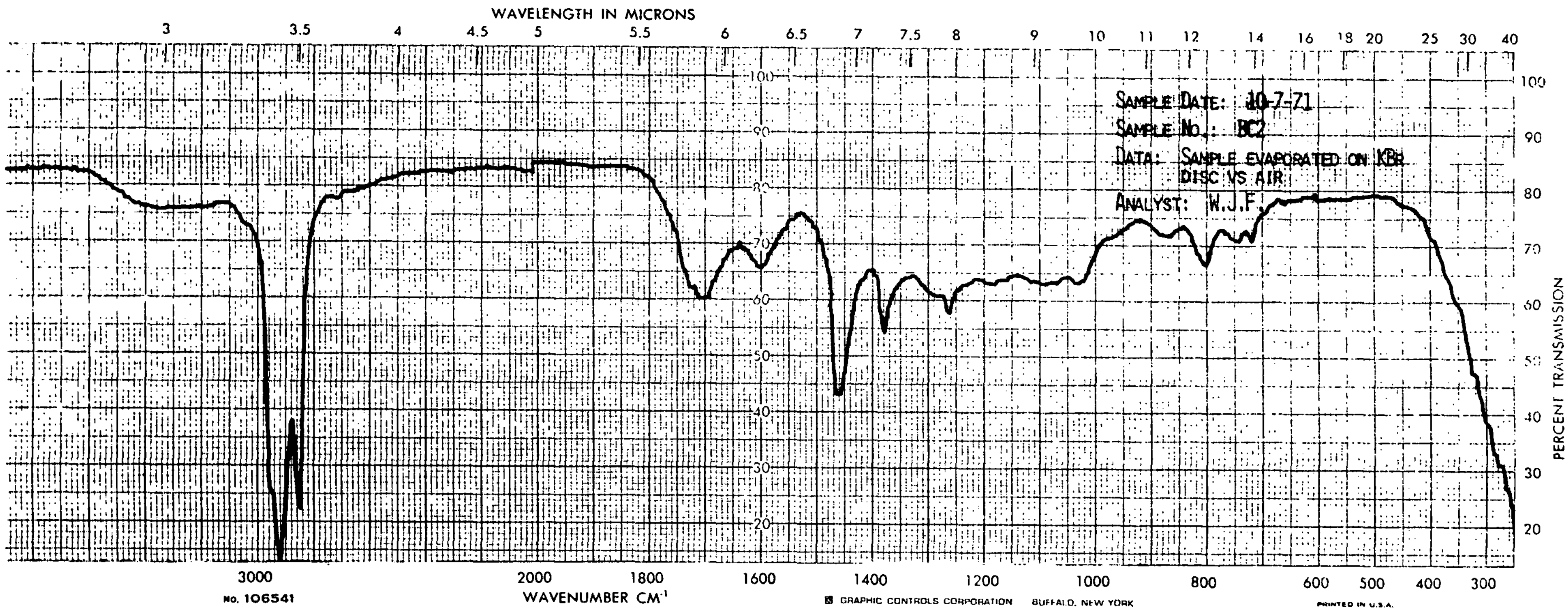
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
100
90
80
70
60
50
40
30
20
PERCENT TRANSMISSION
SAMPLE DATE: 10-7-71
SAMPLE NO.: BC2
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
WAVENUMBER CM⁻¹
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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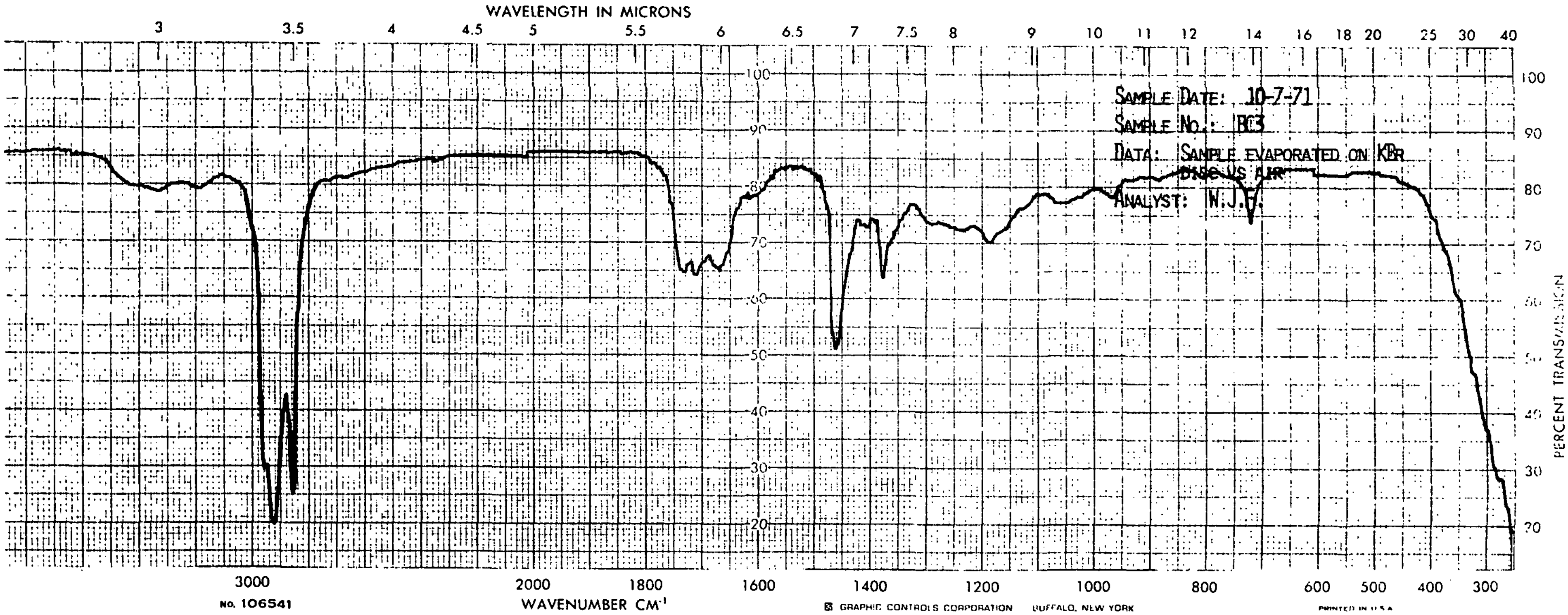
Figure B-9



WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 10-7-71
SAMPLE NO.: BC3
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
100 90 80 70 60 50 40 30 20
PERCENT TRANSMISSION
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
NO. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure B-10

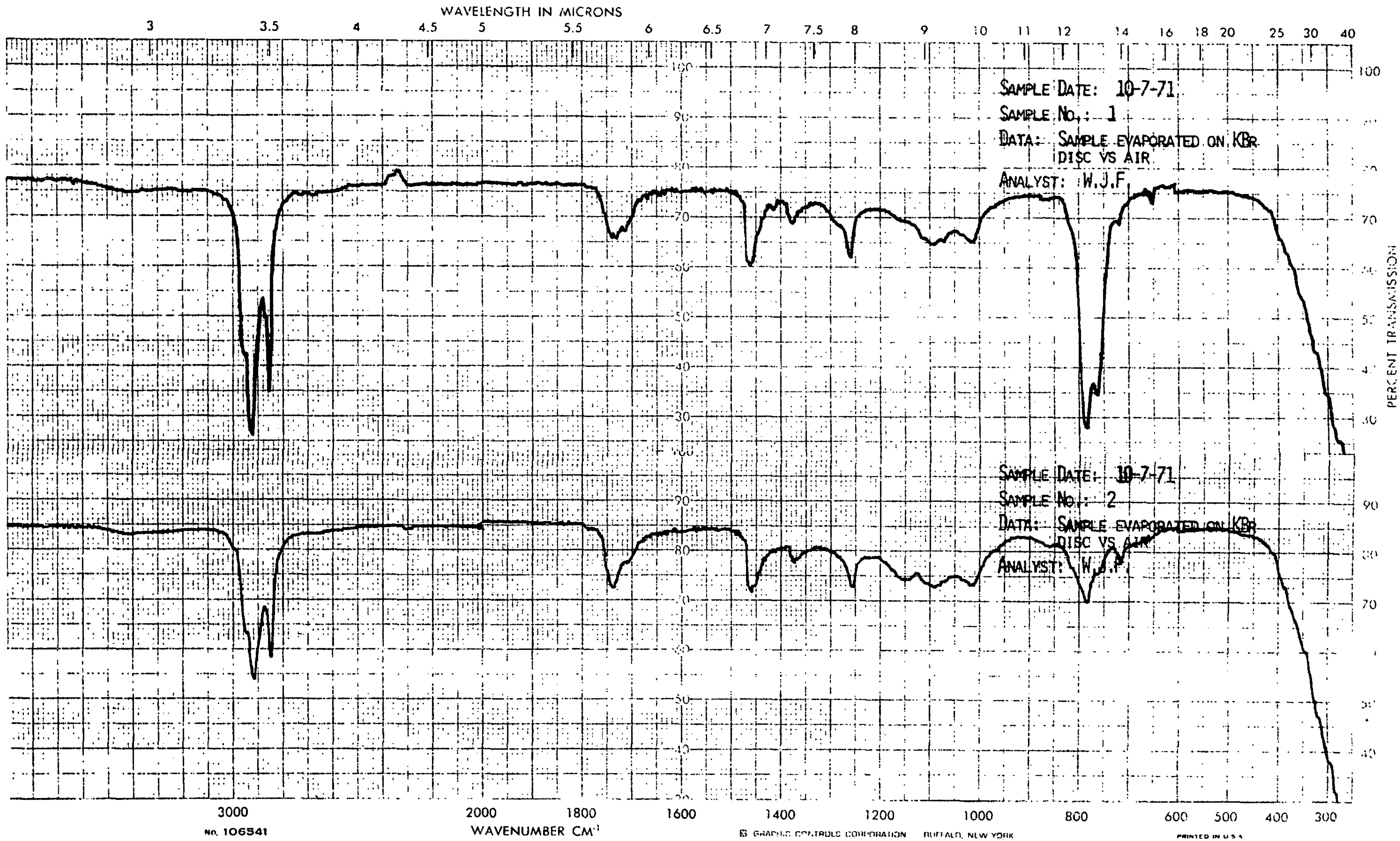
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 10-7-71
SAMPLE NO.: 1
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE NO.: 2
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 70 30 90 80 70 40
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
No. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure B-11

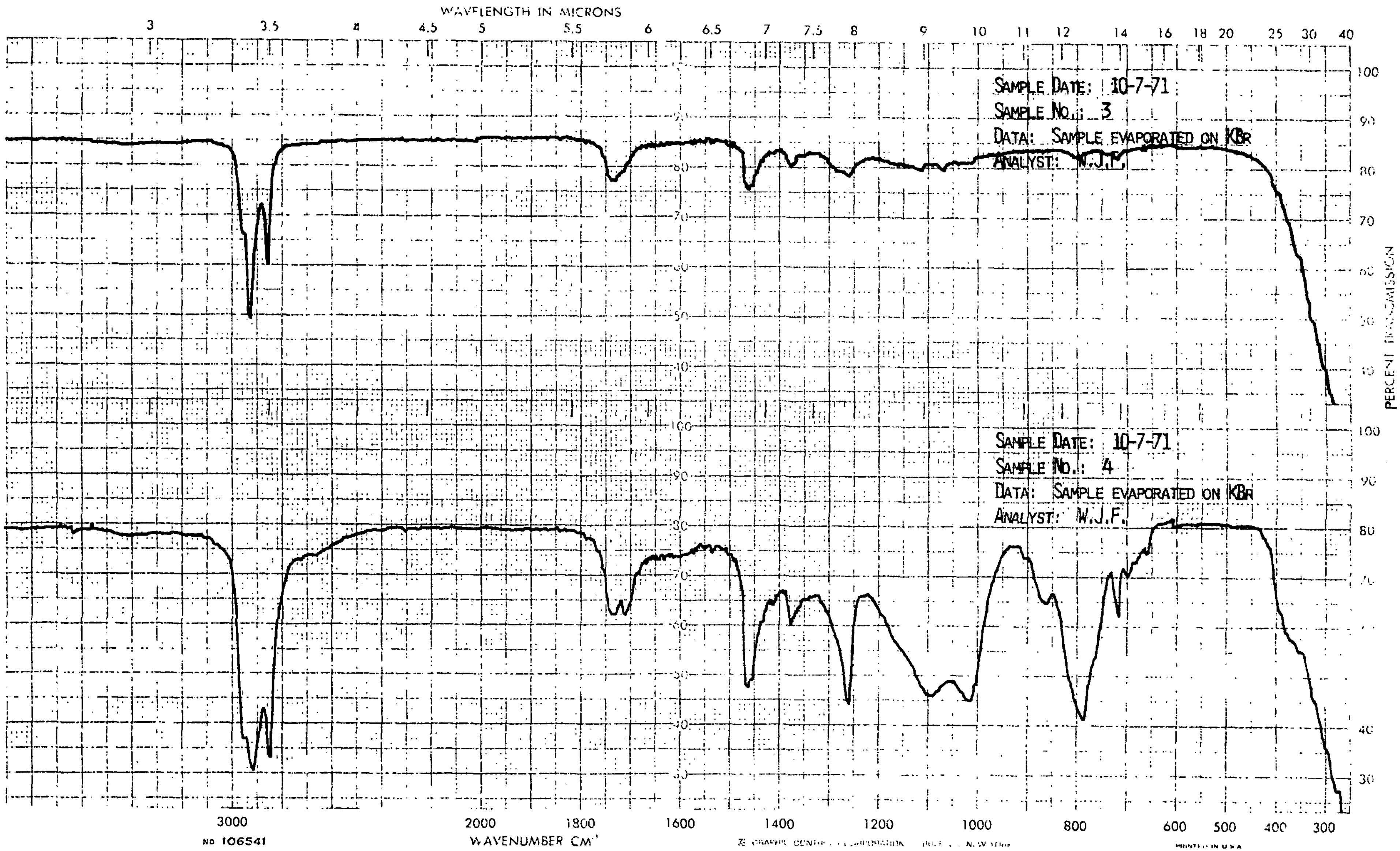

WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 10-7-71
SAMPLE NO.: 3
DATA: SAMPLE EVAPORATED ON KBR
ANALYST: W.J.F.
SAMPLE DATE: 10-7-71
SAMPLE NO.: 4
DATA: SAMPLE EVAPORATED ON KBR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40
100 90 80 70 40 30
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
No 106541

Figure B-12

APPENDIX C

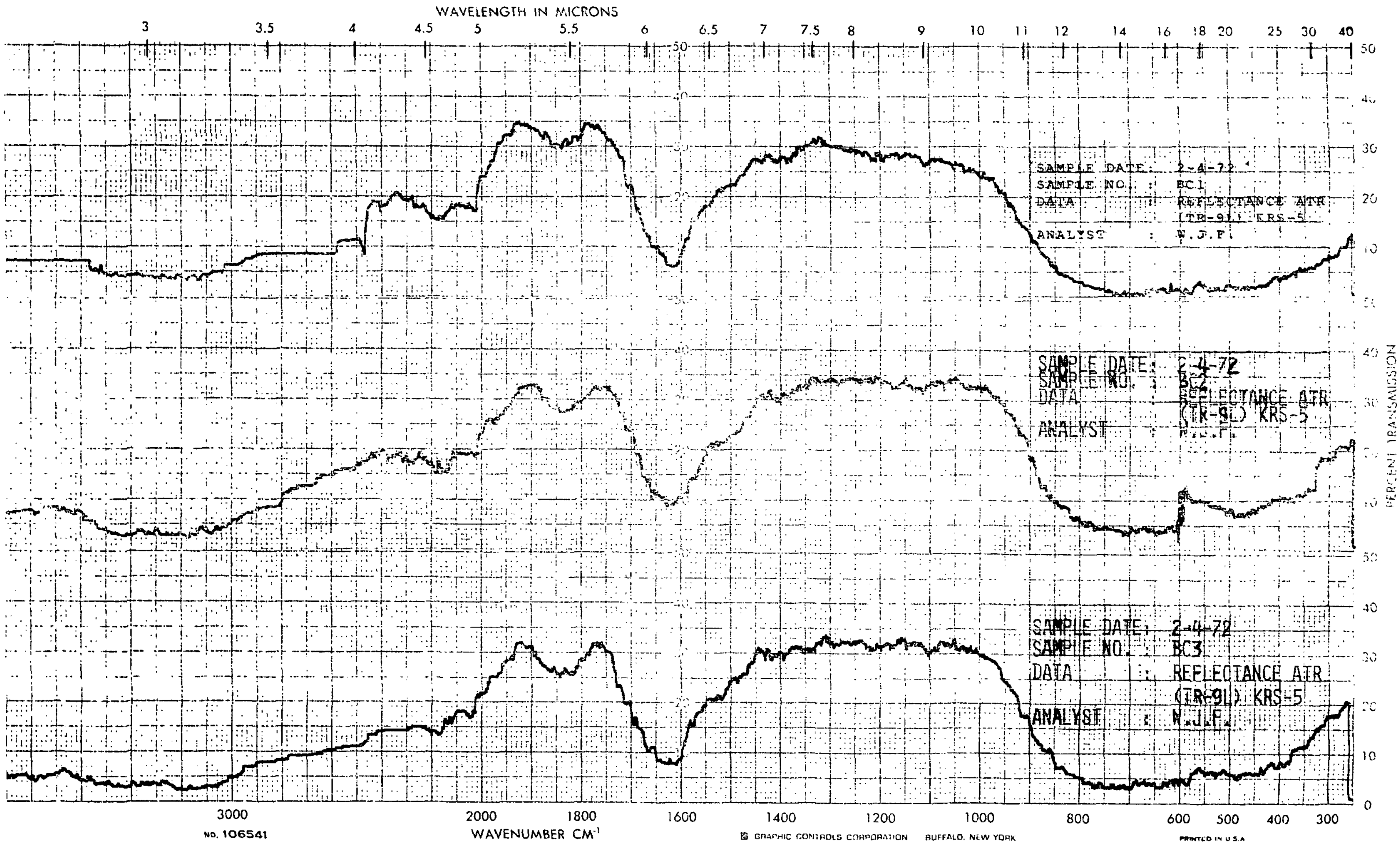
IR SPECTROPHOTOMETRIC SCANS,

FEBRUARY 4, 1972 FIELD SURVEY;

REFLECTANCE ATR(TR-9L)KRS-5

CCl_4 EXTRACT

KBr EVAPORATE



WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE : 2-4-72
SAMPLE NO. : BC1
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE : 2-4-72
SAMPLE NO. : BC2
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE : 2-4-72
SAMPLE NO. : BC3
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
PERCENT TRANSMISSION
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-1

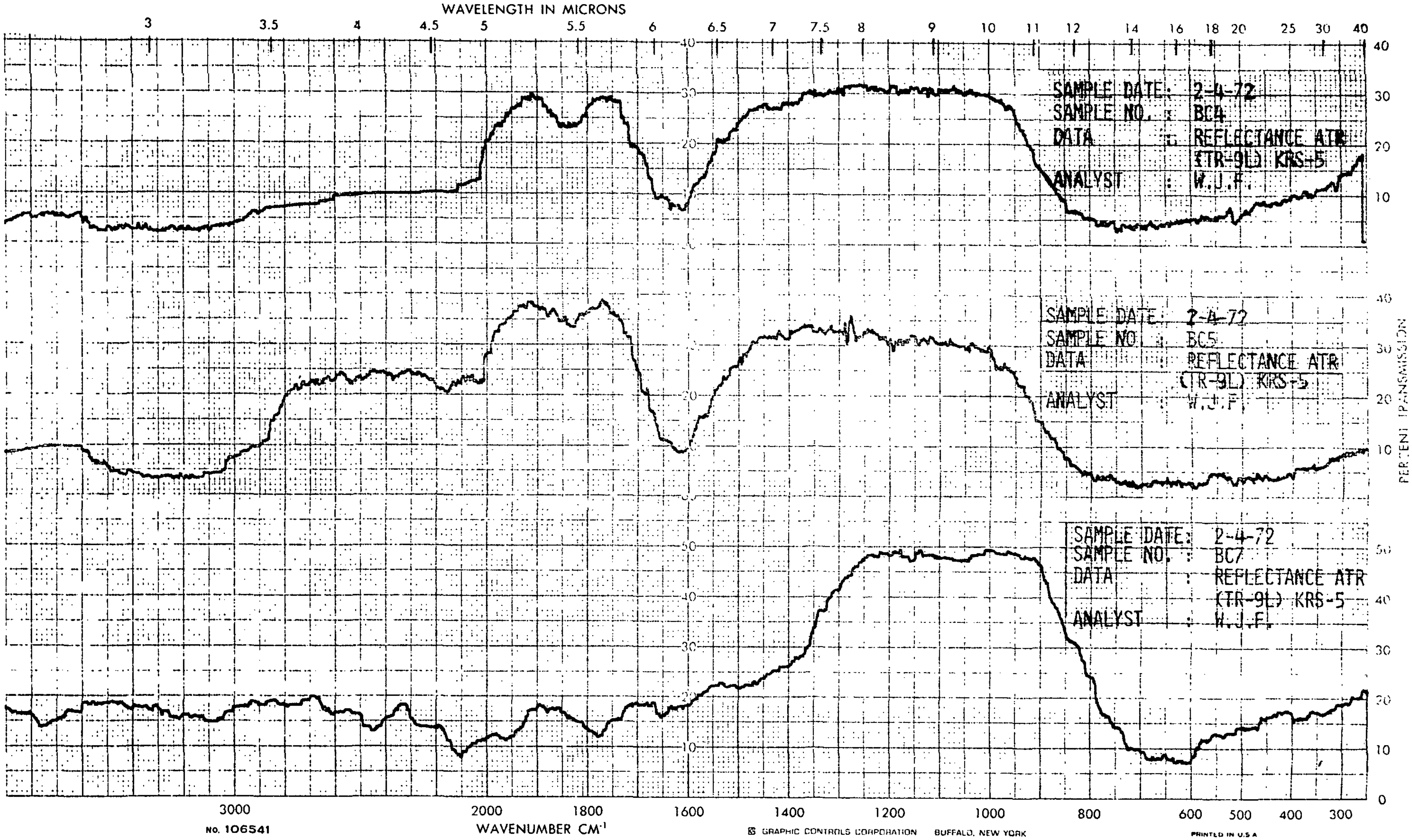
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO. : BC4
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO : BC5
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO. : BC7
DATA : REFLECTANCE ATR
(TR-9L) KRS-5
ANALYST : W.J.F.
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
WAVENUMBER CM-1
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-2

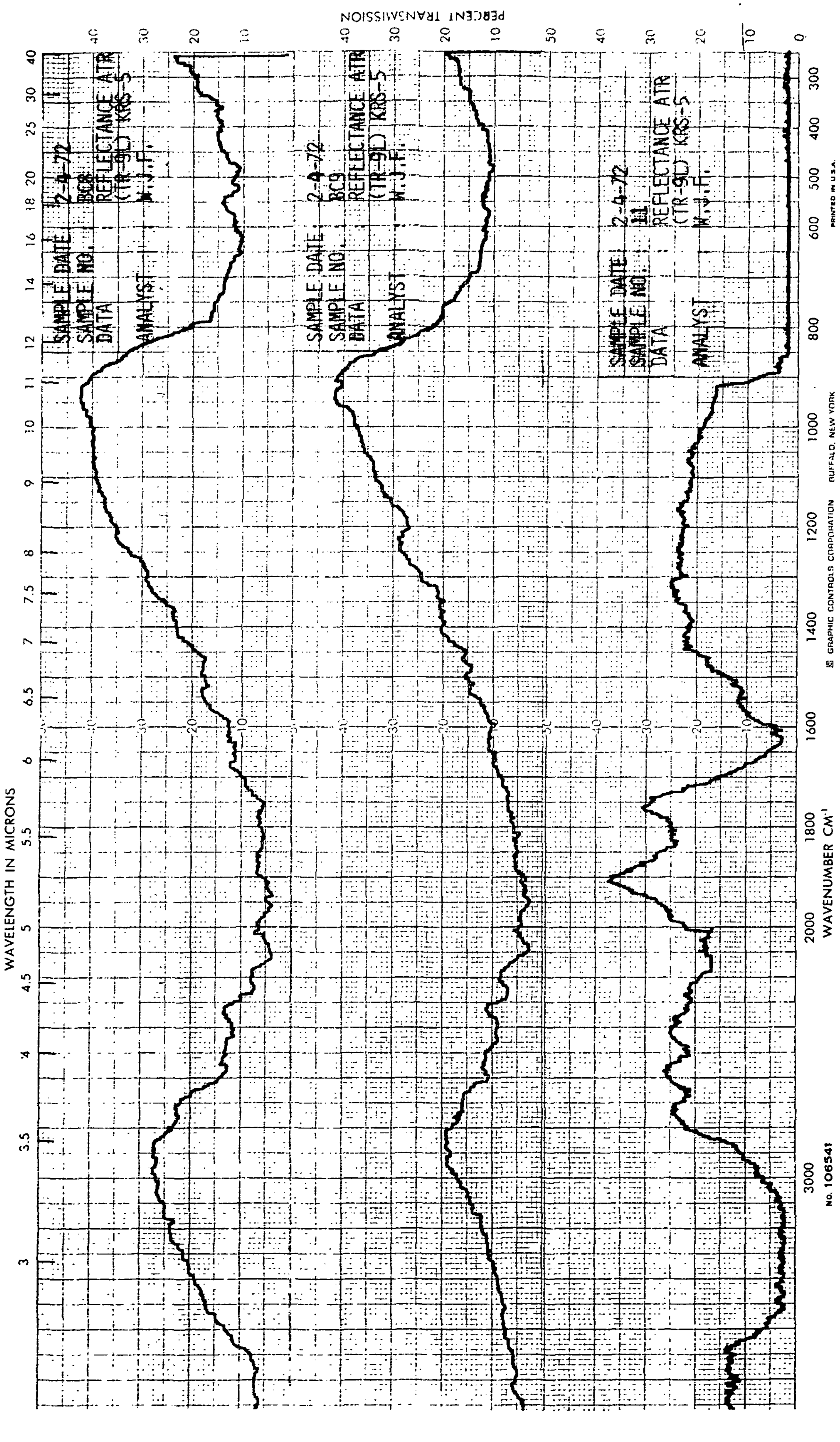
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE 2-4-72
SAMPLE NO. BC8
DATA REFLECTANCE ATR (TR-9D) KRS-5
ANALYST W.J.F.
SAMPLE DATE 2-4-72
SAMPLE NO. BC9
DATA REFLECTANCE ATR (TR-9D) KRS-5
ANALYST W.J.F.
SAMPLE DATE 2-4-72
SAMPLE NO. L1
DATA REFLECTANCE ATR (TR-9D) KRS-5
ANALYST W.J.F.
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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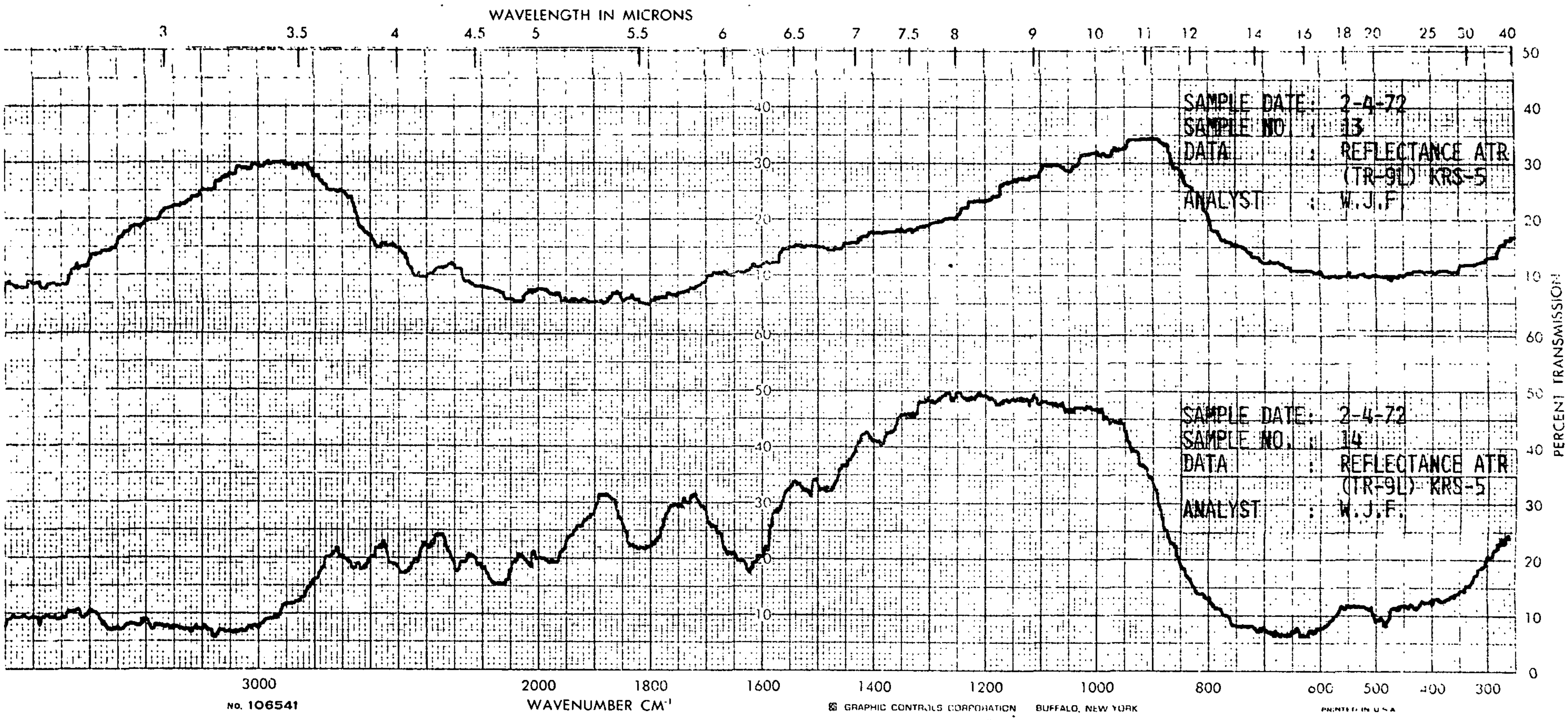
Figure C-3



WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO. : 13
DATA : REFLECTANCE ATR (TR-9L) KRS-5
ANALYST : W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO. : 14
DATA : REFLECTANCE ATR (TR-9L) KRS-5
ANALYST : W.J.F.
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
WAVENUMBER CM⁻¹
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK

Figure C-4

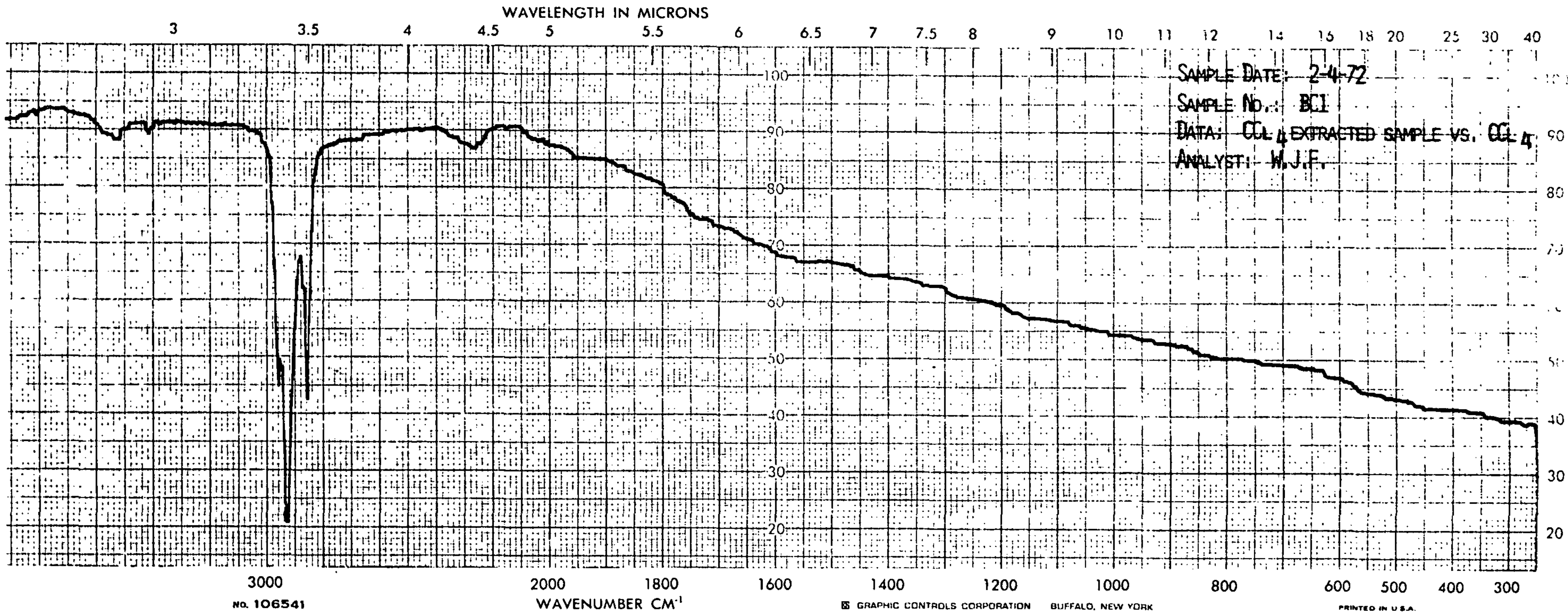

WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC1
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40 30 20
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
NO. 106541
WAVENUMBER CM^{-1}
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure C-5

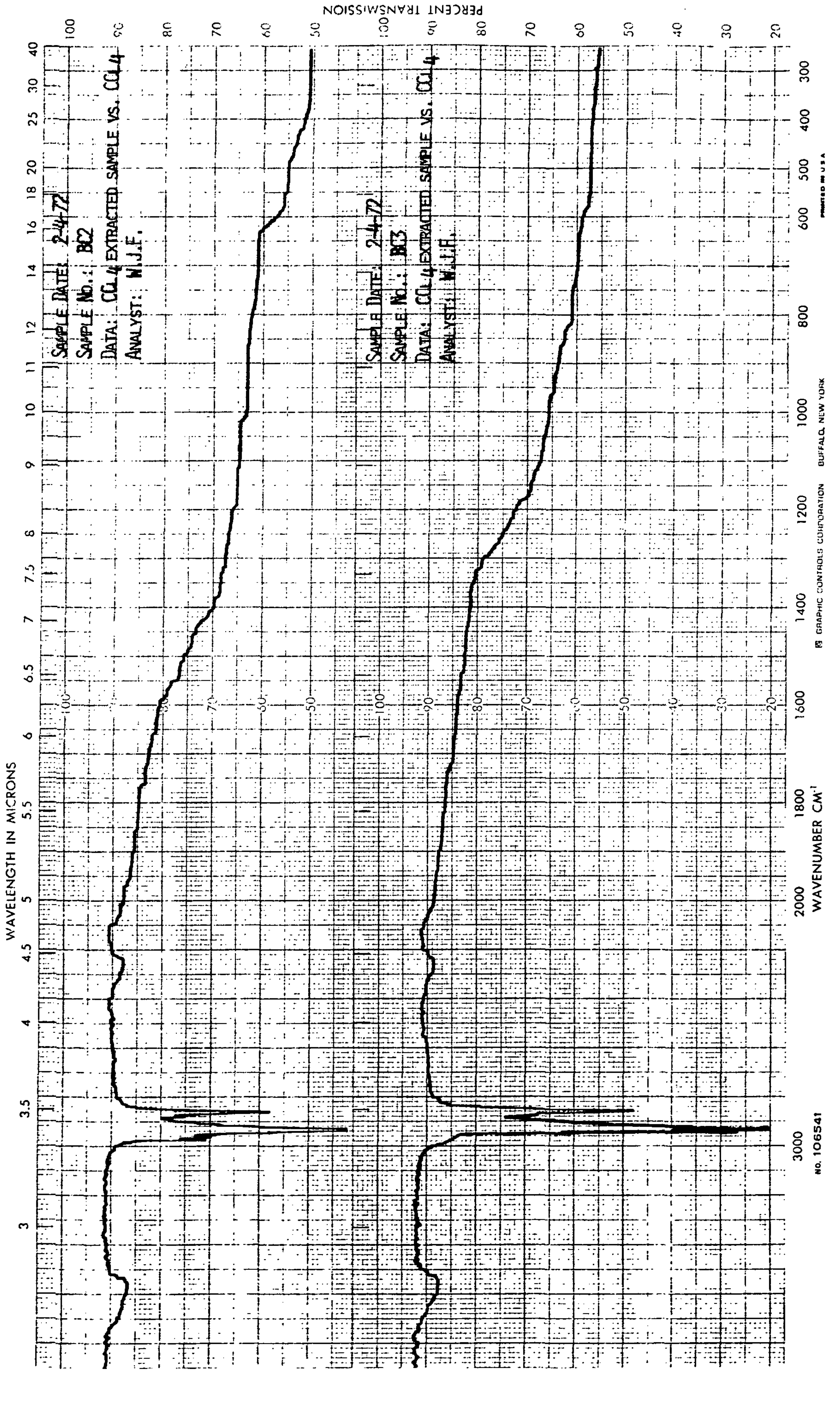
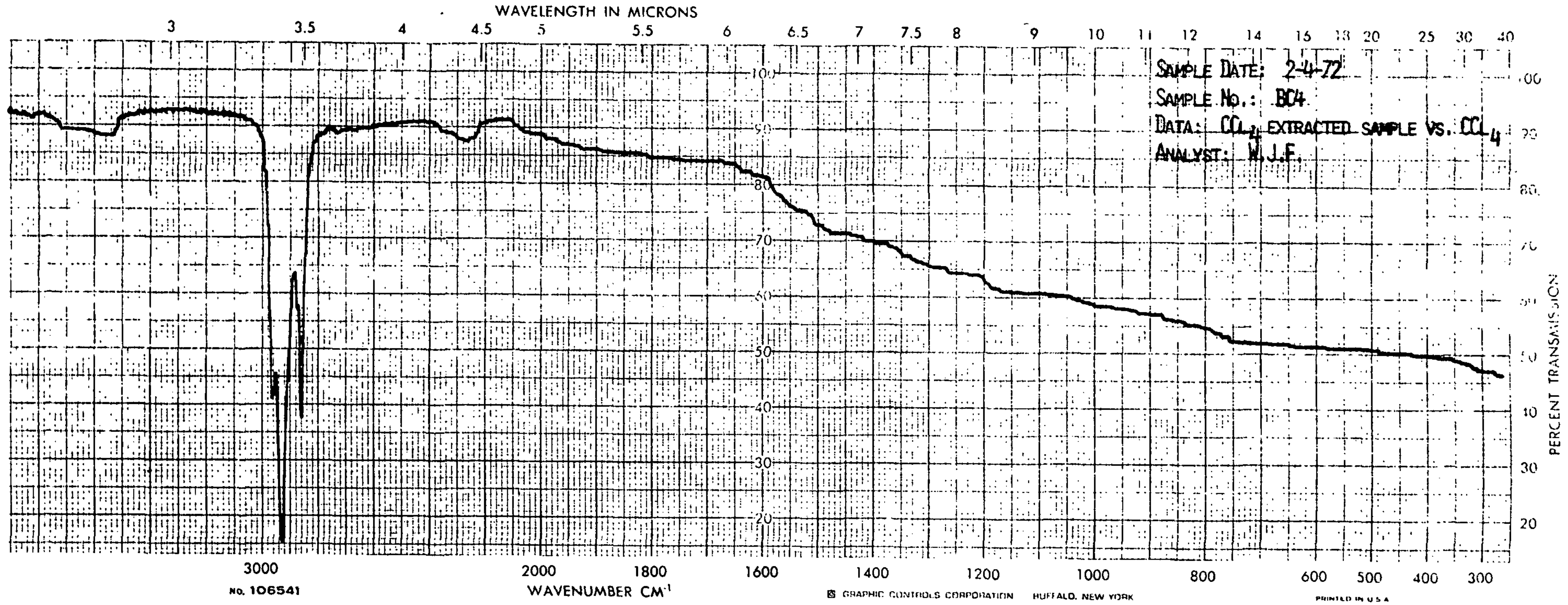

PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM-1
SAMPLE DATE: 2-4-72
SAMPLE No.: BC2
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE No.: BC3
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541

Figure C-6



WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE No.: BC4
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
100
90
80
70
60
50
40
30
20
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
No. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure C-7

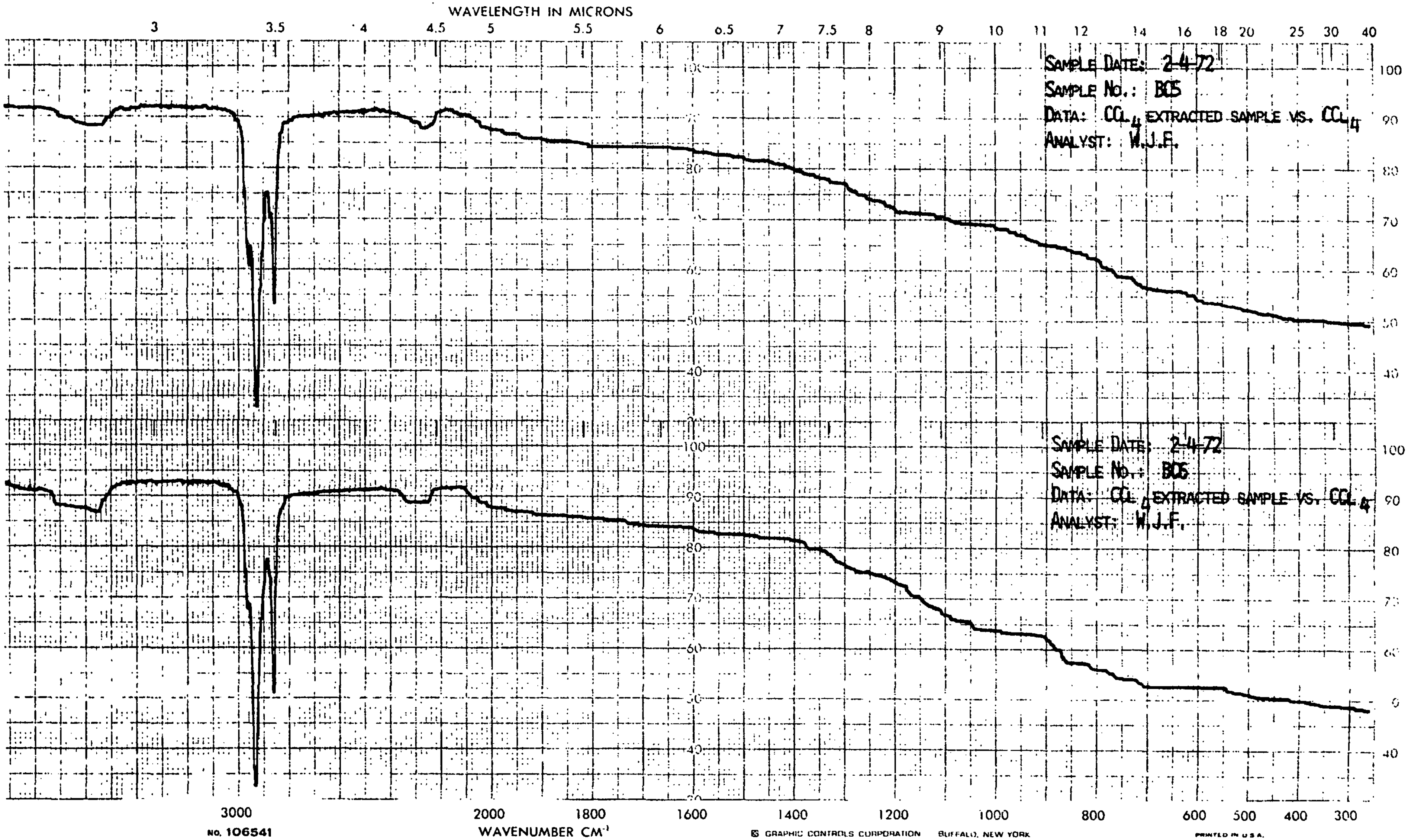

WAVELENGTH IN MICRONS
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC5
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC6
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
PERCENT TRANSMISSION
WAVENUMBER CM⁻¹
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-8

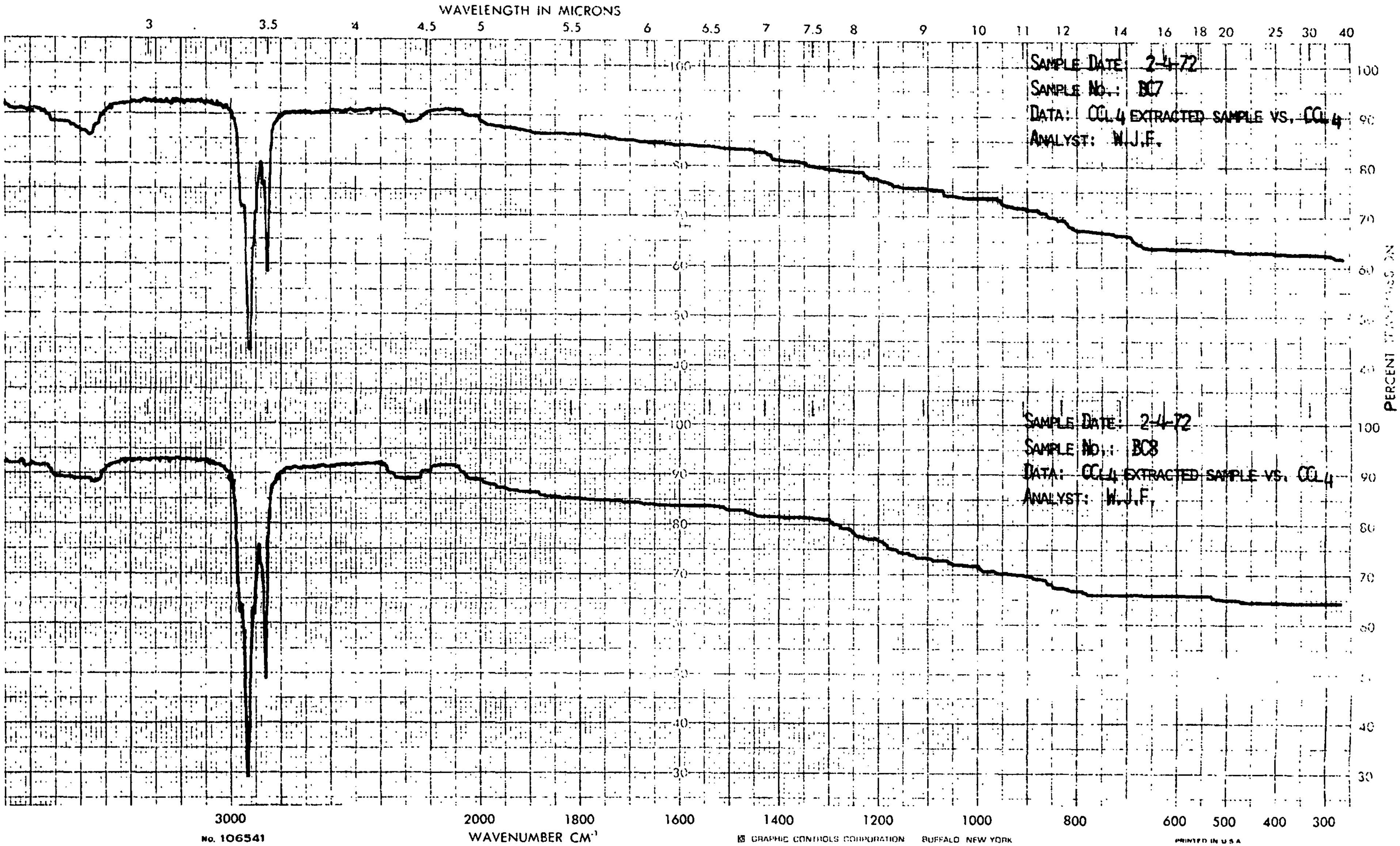
WAVELENGTH IN MICRONS
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC7
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC8
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
PERCENT
WAVENUMBER CM⁻¹
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO NEW YORK
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Figure C-9

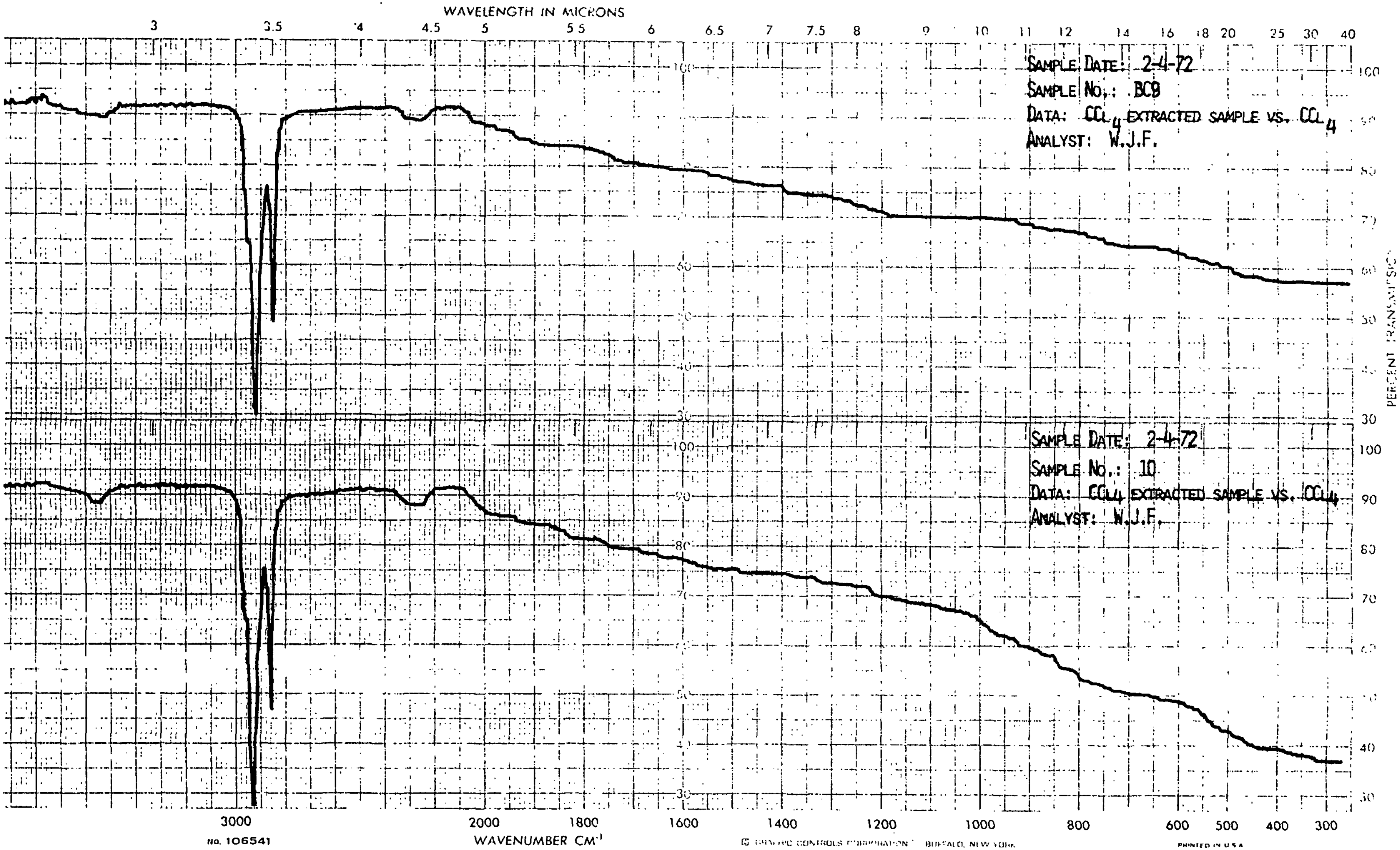
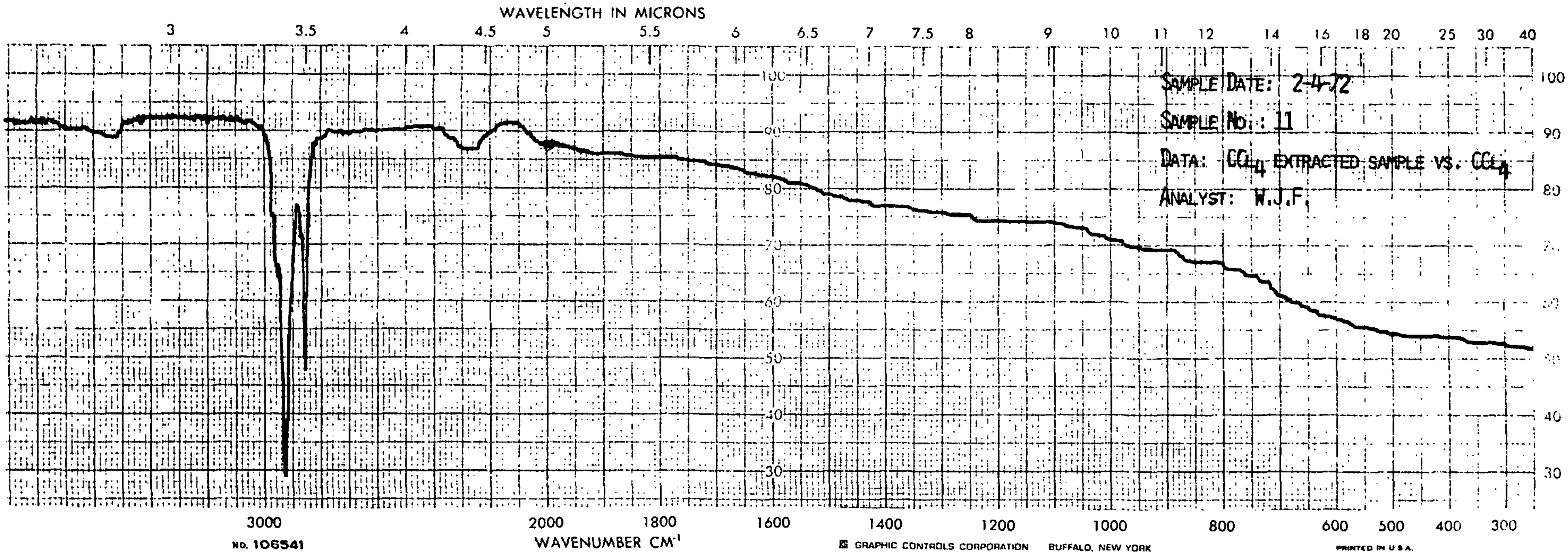

WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC9
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: 10
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
100
90
80
70
60
50
40
30
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
No. 106541
WAVENUMBER CM⁻¹
PRINTED IN U.S.A.

Figure C-10



WAVELENGTH IN MICRONS
PERCENT TRANSMISSION
WAVENUMBER CM⁻¹
SAMPLE DATE: 2-4-72
SAMPLE NO.: 11
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: W.J.F.
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-11

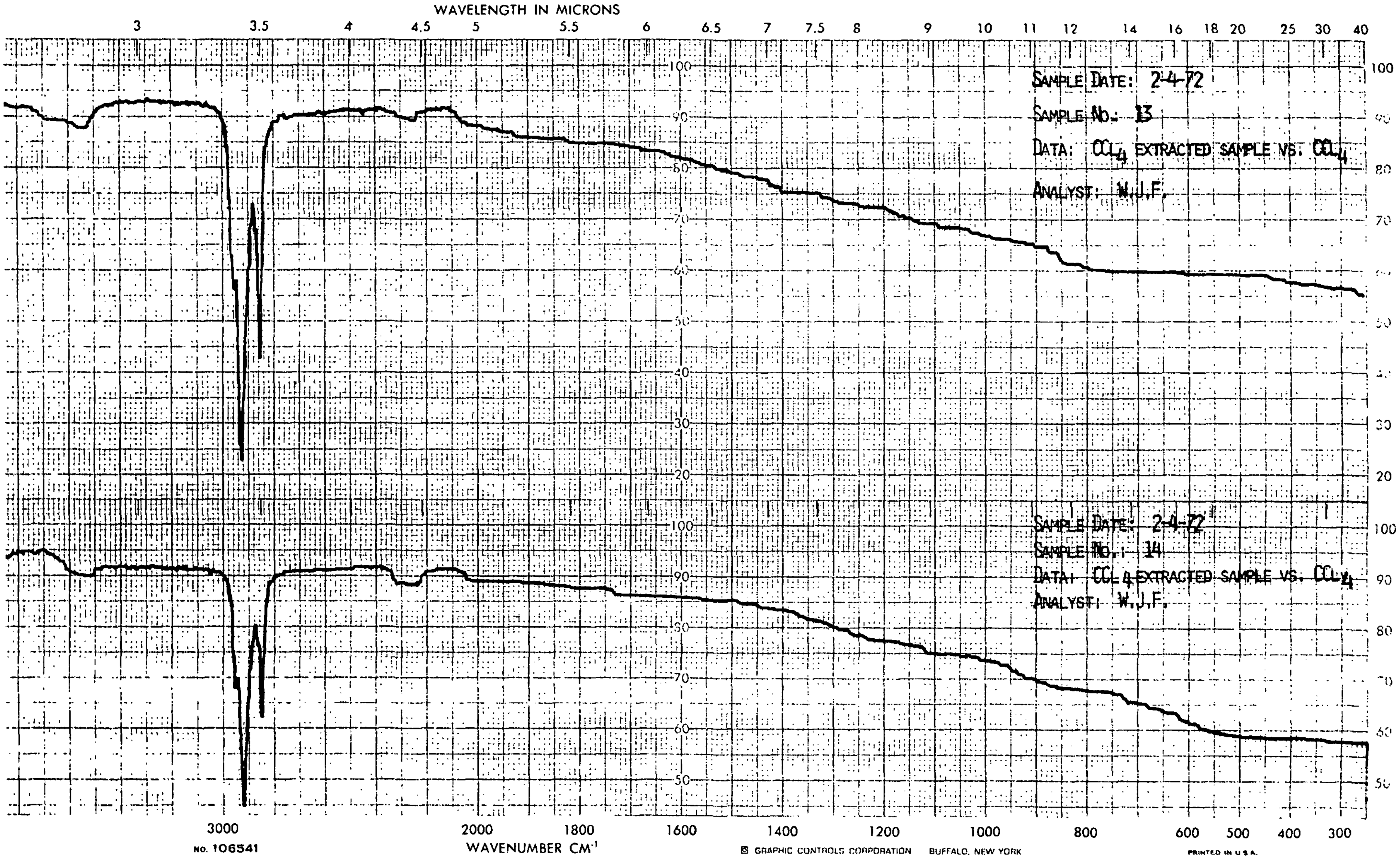
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 2-4-72
SAMPLE No. 13
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE No. 14
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40 30 20
100 90 80 70 60 50
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
No. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure C-12

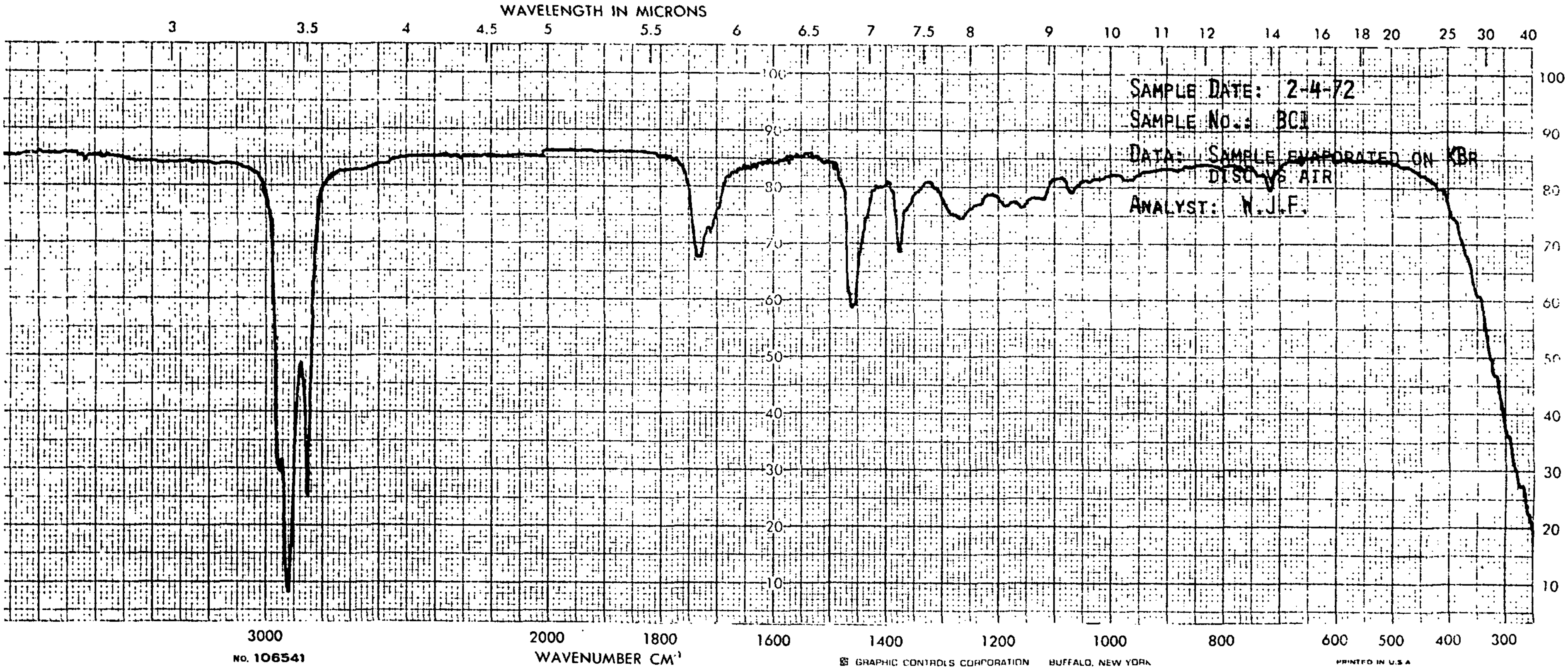
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
100
90
80
70
60
50
40
30
20
10
PERCENT TRANSMISSION
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC1
DATA: SAMPLE EVAPORATED ON KBR
DISC VS AIR
ANALYST: N.J.F.
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
NO. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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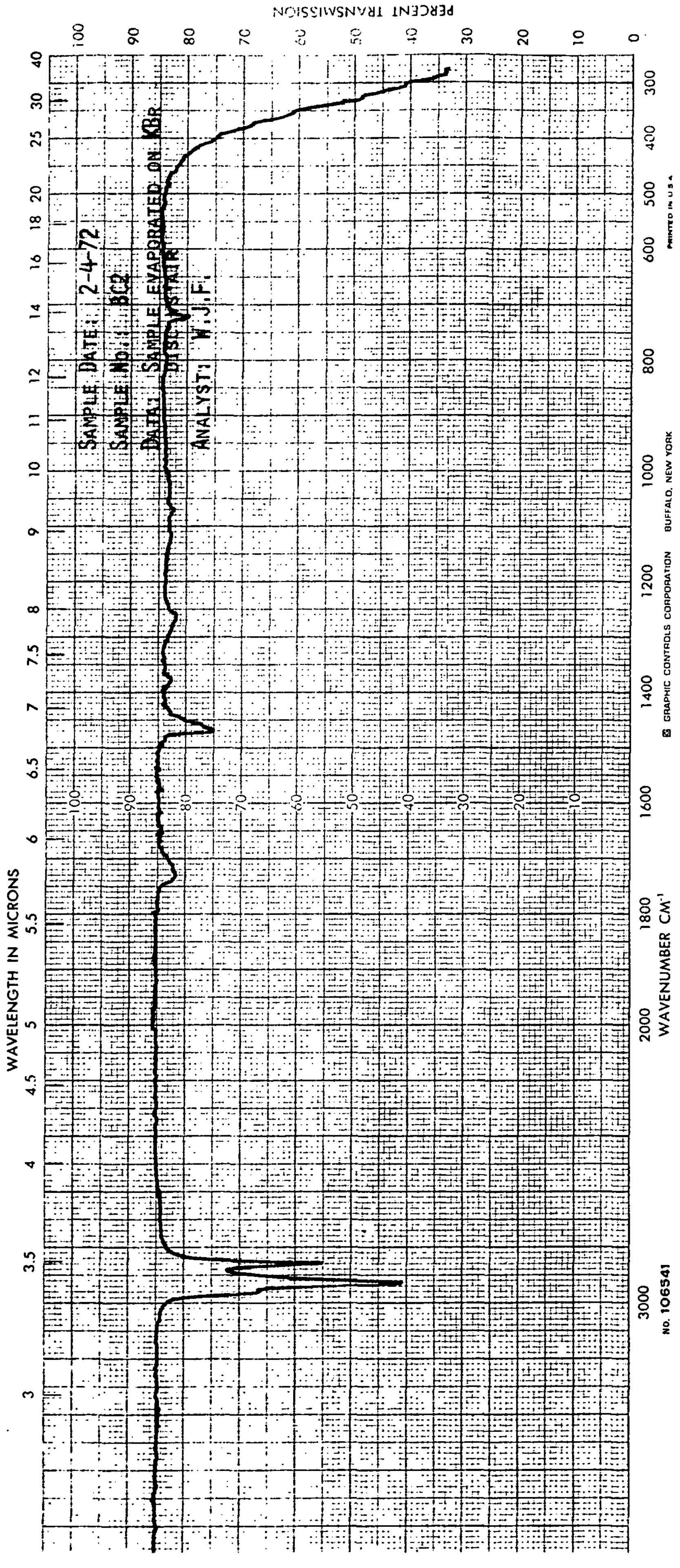
Figure C-13



PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC2
DATA: SAMPLE EVAPORATED ON KBr
ANALYST: W.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541
PRINTED IN U.S.A.

Figure C-14

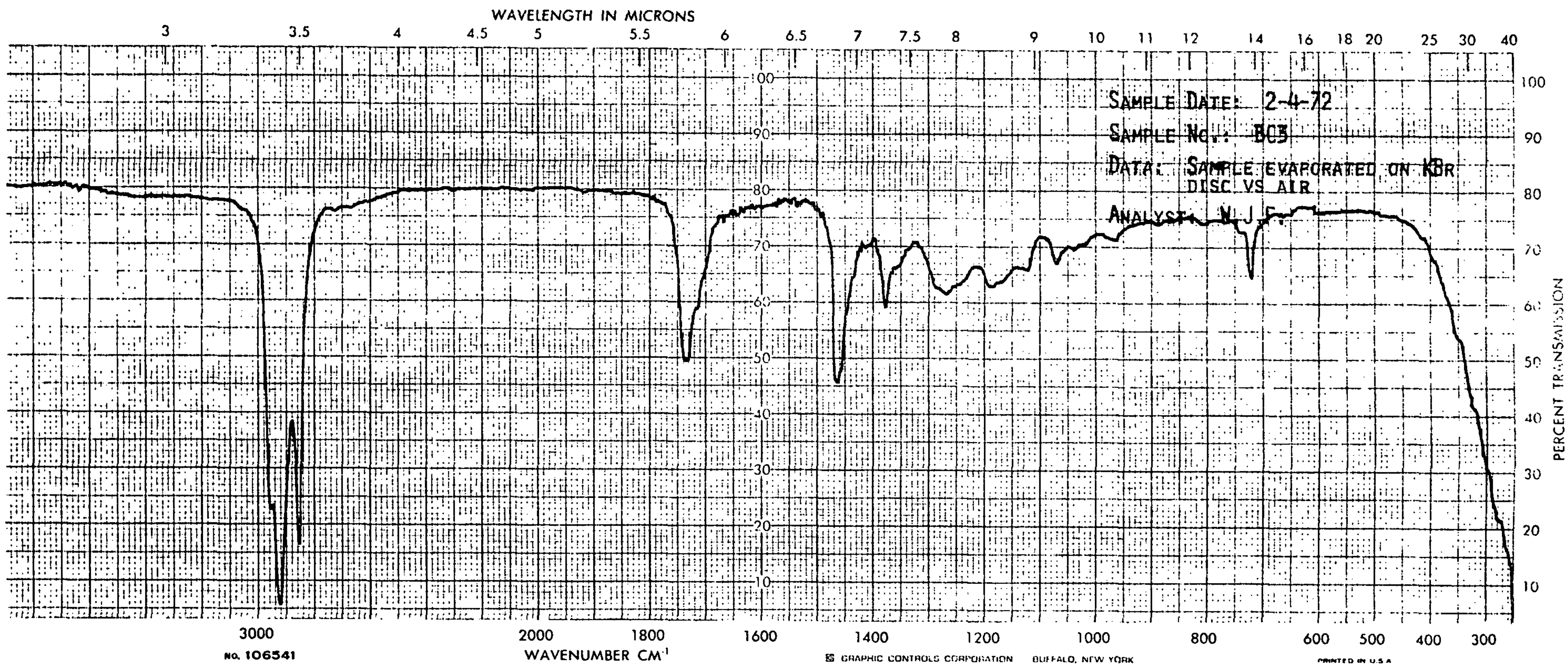

WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC3
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40 30 20 10
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-15

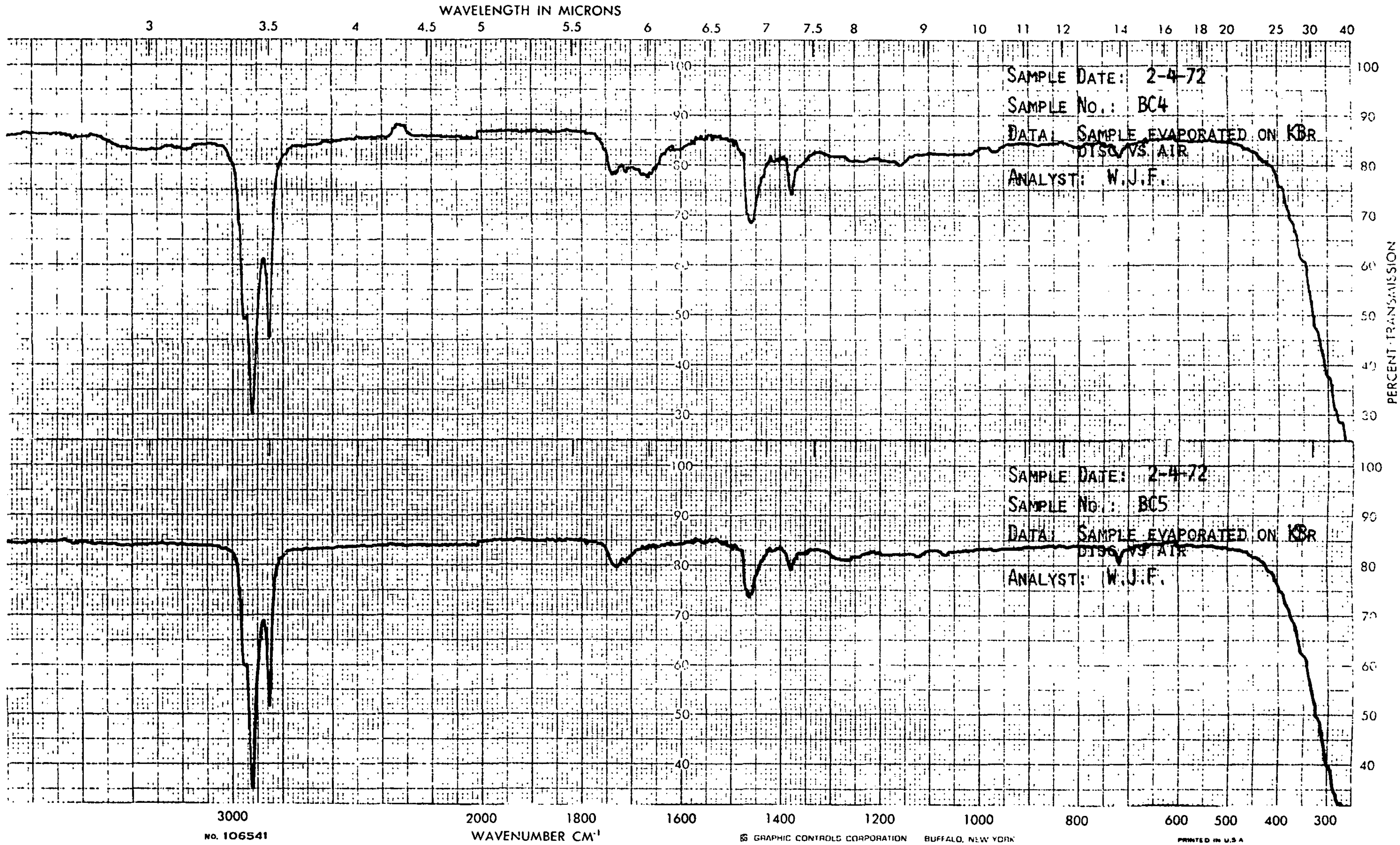
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC4
DATA: SAMPLE EVAPORATED ON KBR
DTGS VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC5
DATA: SAMPLE EVAPORATED ON KBR
DTGS VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
NO. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION
BUFFALO, NEW YORK
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Figure C-16

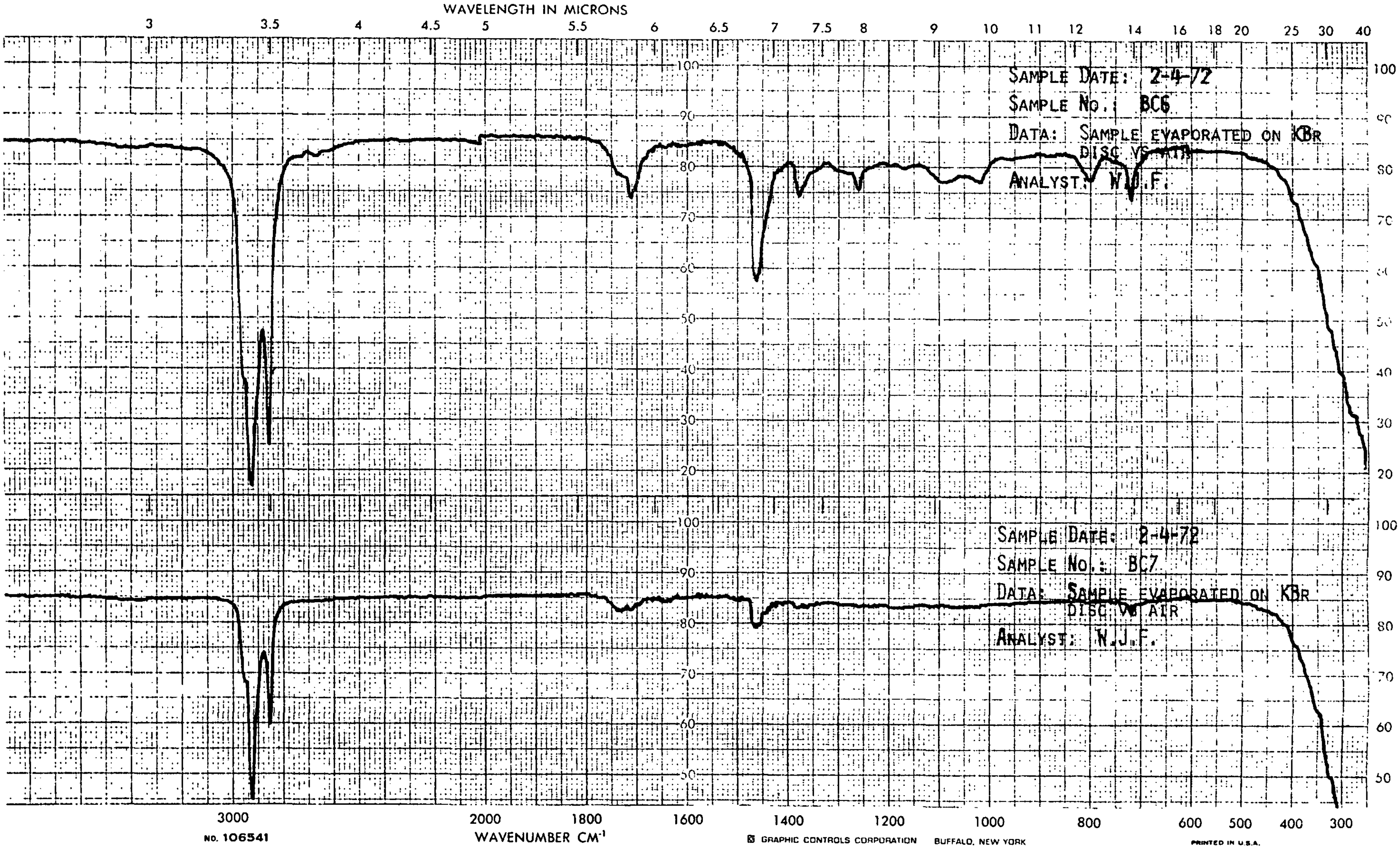
WAVELENGTH IN MICRONS
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC6
DATA: SAMPLE EVAPORATED ON KBR
DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC7
DATA: SAMPLE EVAPORATED ON KBR
DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
WAVENUMBER CM⁻¹
NO. 106541
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Figure C-17

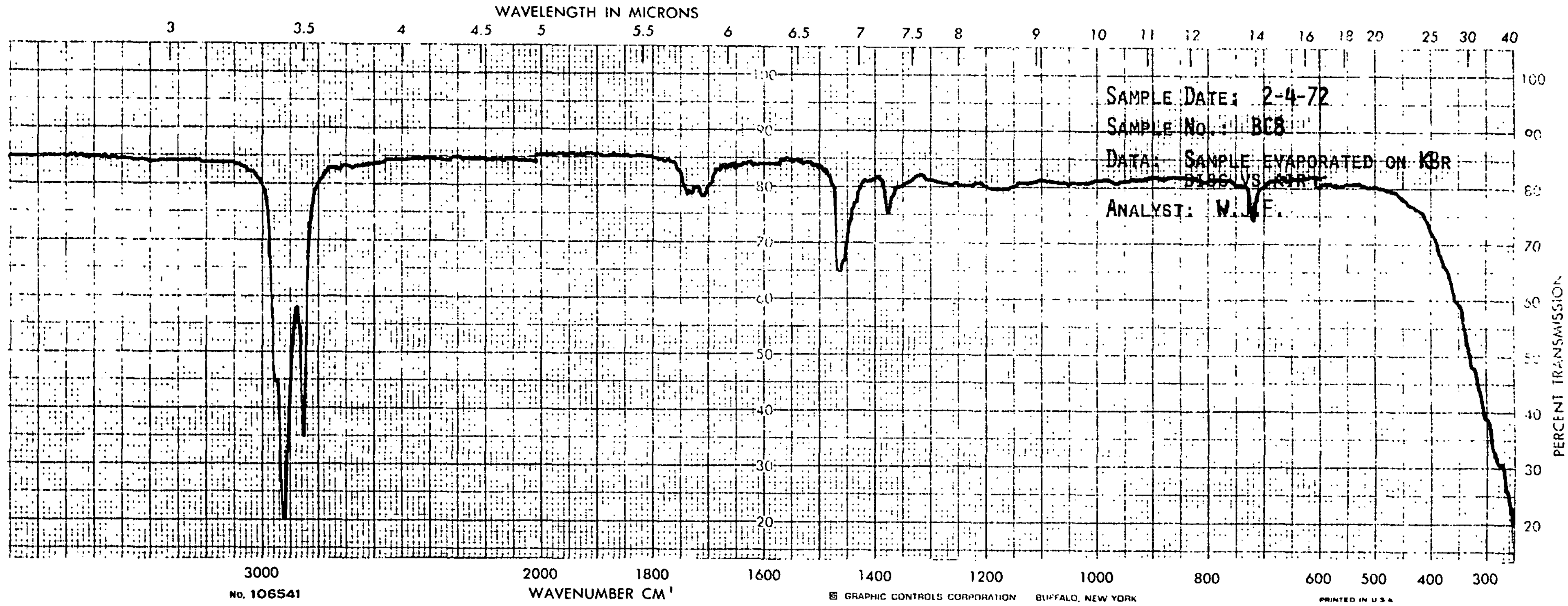
WAVELENGTH IN MICRONS
PERCENT TRANSMISSION
WAVENUMBER CM⁻¹
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC8
DATA: SAMPLE EVAPORATED ON KBr
ANALYST: W.J.F.
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure C-18

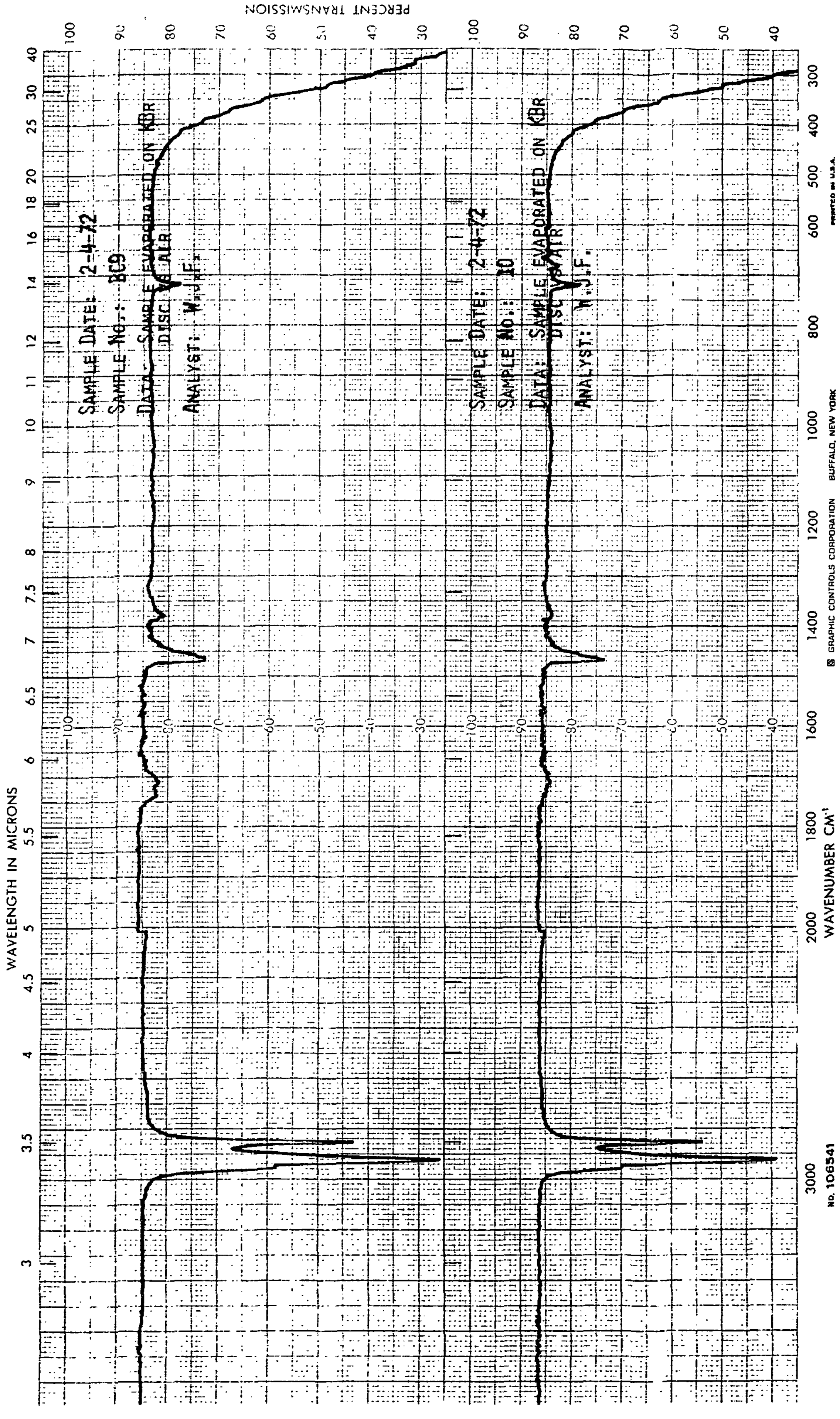
PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
SAMPLE DATE: 2-4-72
SAMPLE NO.: BC9
DATA: SAMPLE EVAPORATED ON KBR
DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 2-4-72
SAMPLE NO.: 10
DATA: SAMPLE EVAPORATED ON KBR
DISC VS AIR
ANALYST: W.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541
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Figure C-19

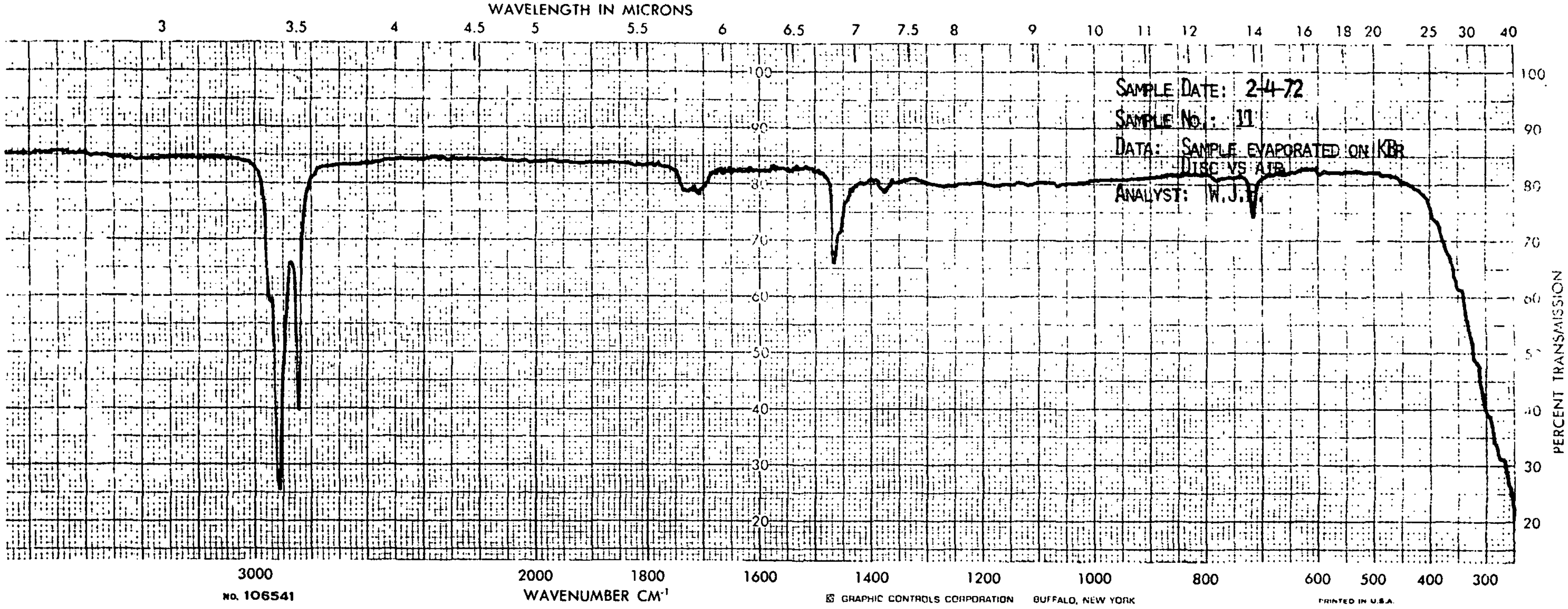
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 2-4-72
SAMPLE NO.: 11
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.
PERCENT TRANSMISSION
100 90 80 70 60 40 30 20
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
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Figure C-20

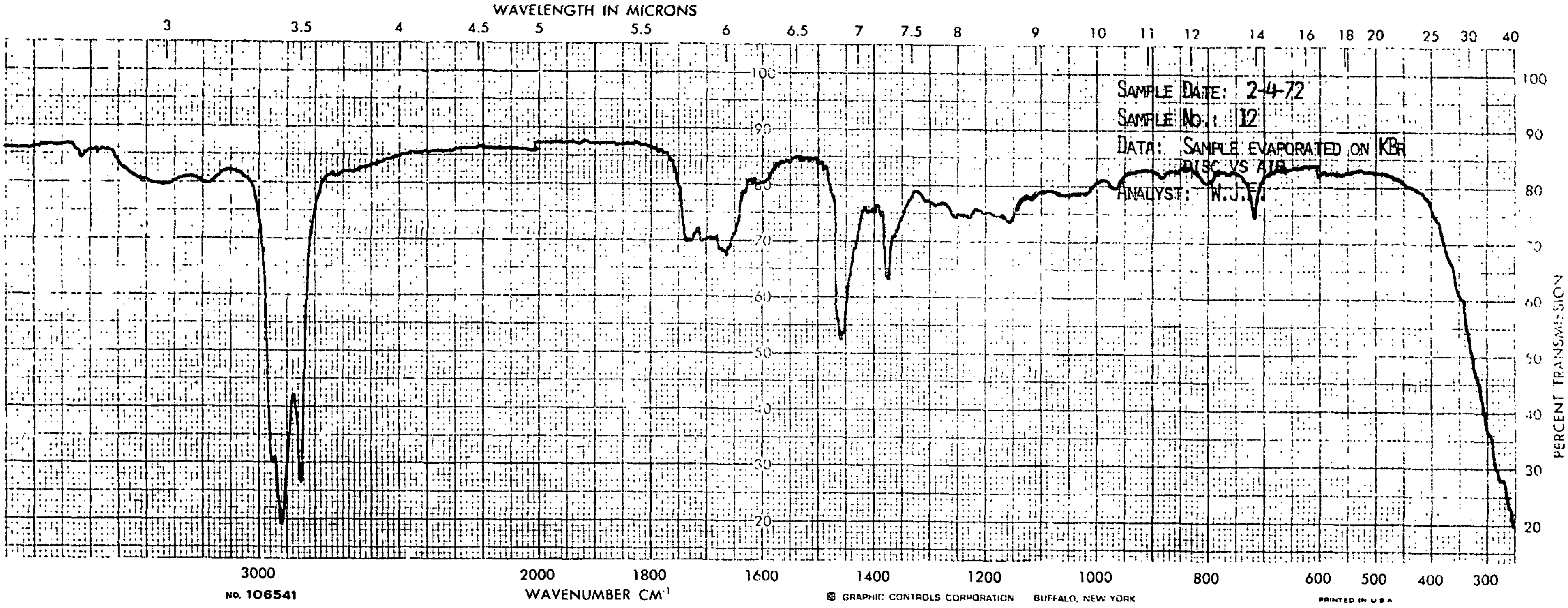
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO.: 12
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.E.
PERCENT TRANSMISSION
100
90
80
70
60
50
40
30
20
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
NO. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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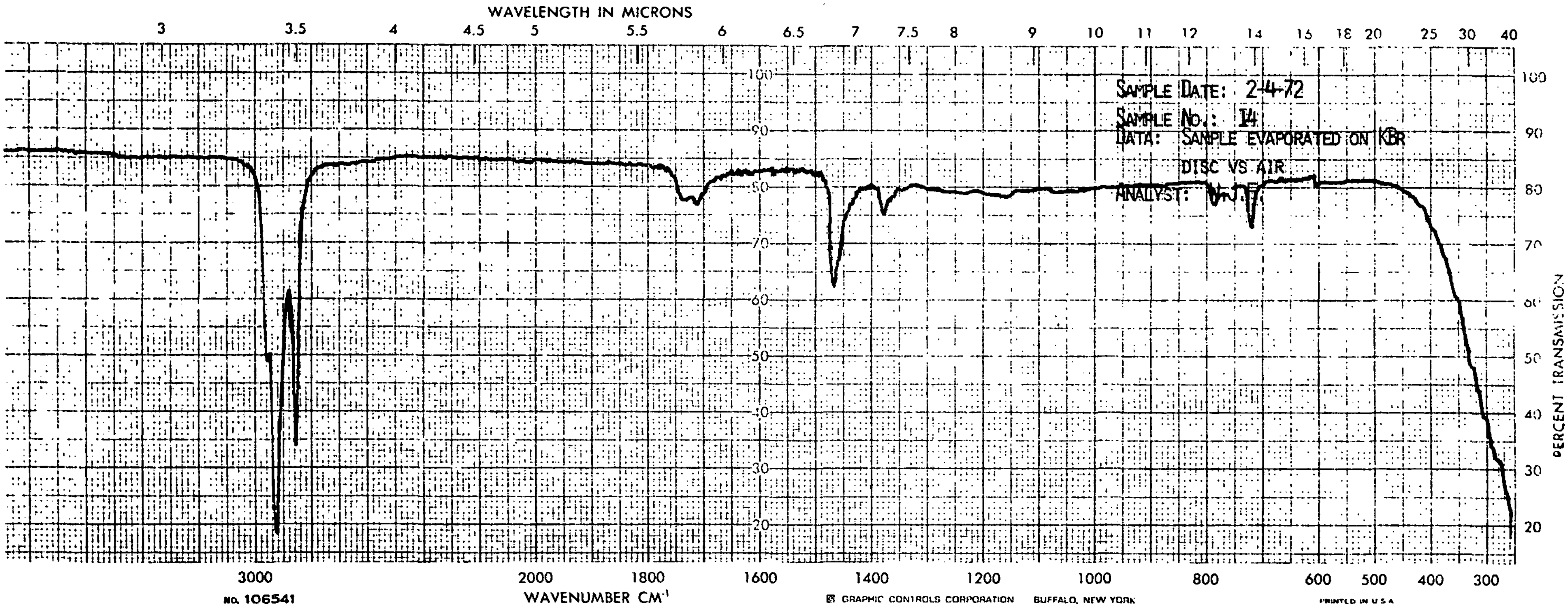
Figure C-21



WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
SAMPLE DATE: 2-4-72
SAMPLE NO.: 14
DATA: SAMPLE EVAPORATED ON KBr
DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100
90
80
70
60
50
40
30
20
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
NO. 106541
WAVENUMBER CM⁻¹
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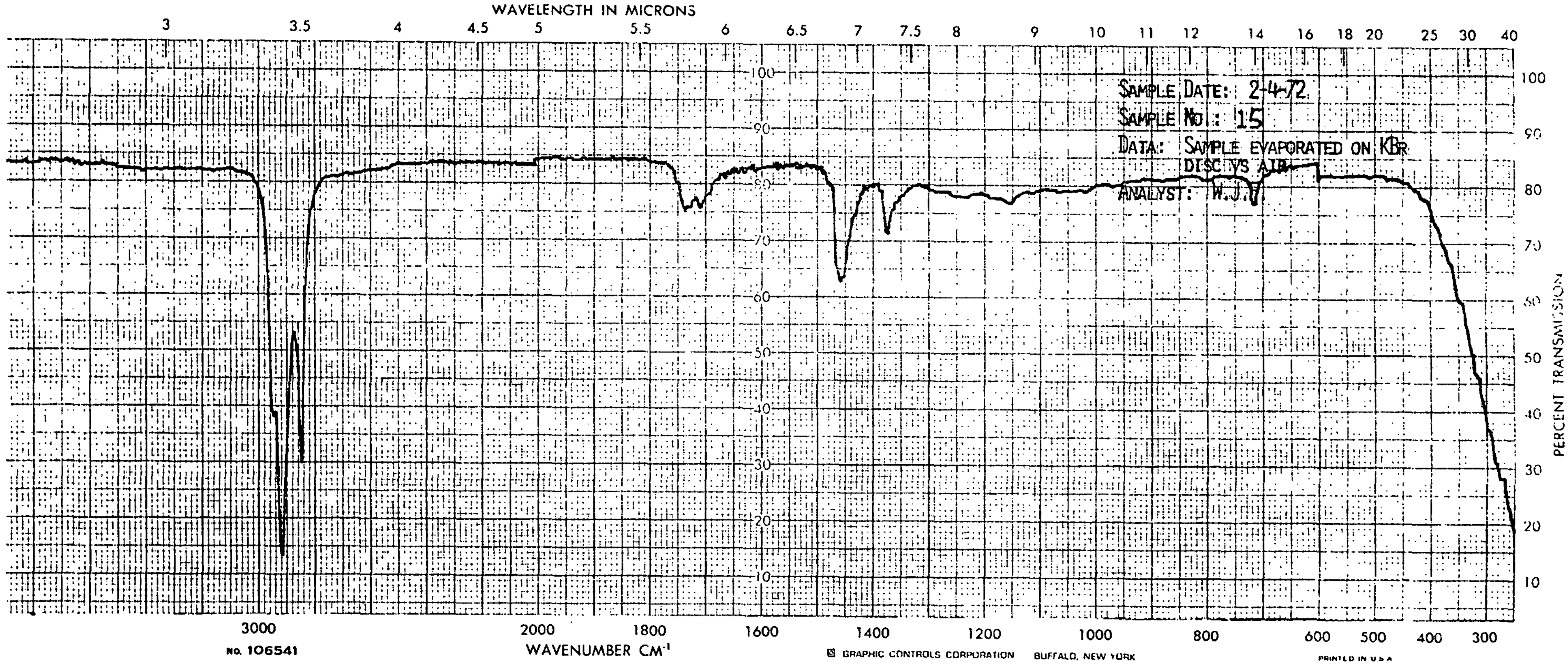
Figure C-22



WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
PERCENT TRANSMISSION
100
90
80
70
60
50
40
30
20
10
SAMPLE DATE: 2-4-72
SAMPLE NO.: 15
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
WAVENUMBER CM⁻¹
NO. 106541
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Figure C-23

APPENDIX D

IR SPECTROPHOTOMETRIC SCANS,

JUNE 8, 1972 FIELD SURVEY;

REFLECTANCE ATR(TR-9L)KRS-5

CCl_4 EXTRACT

KBr EVAPORATE

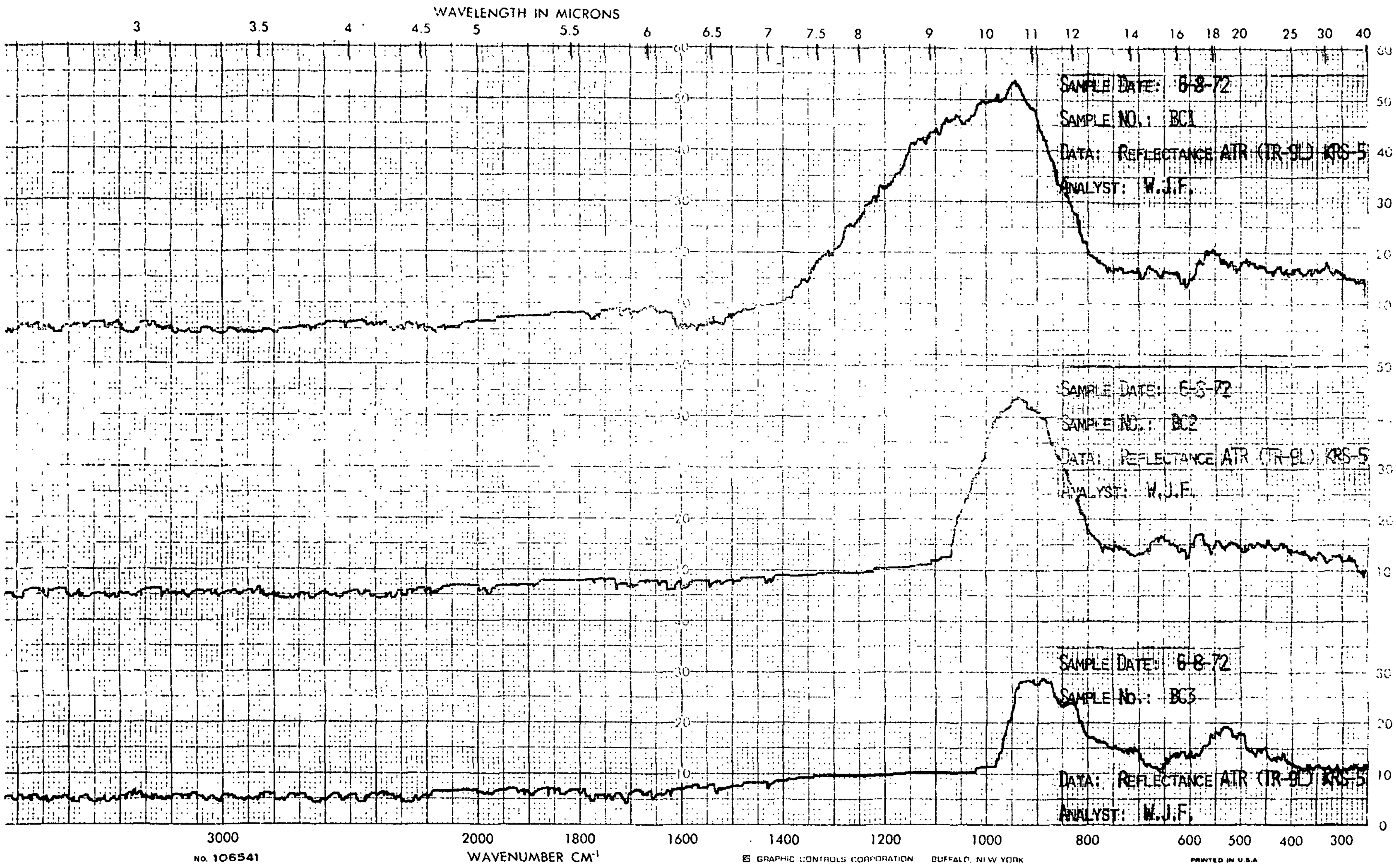
WAVELENGTH IN MICRONS
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC1
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC2
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC3
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
WAVENUMBER CM⁻¹
NO. 106541
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Figure D-1

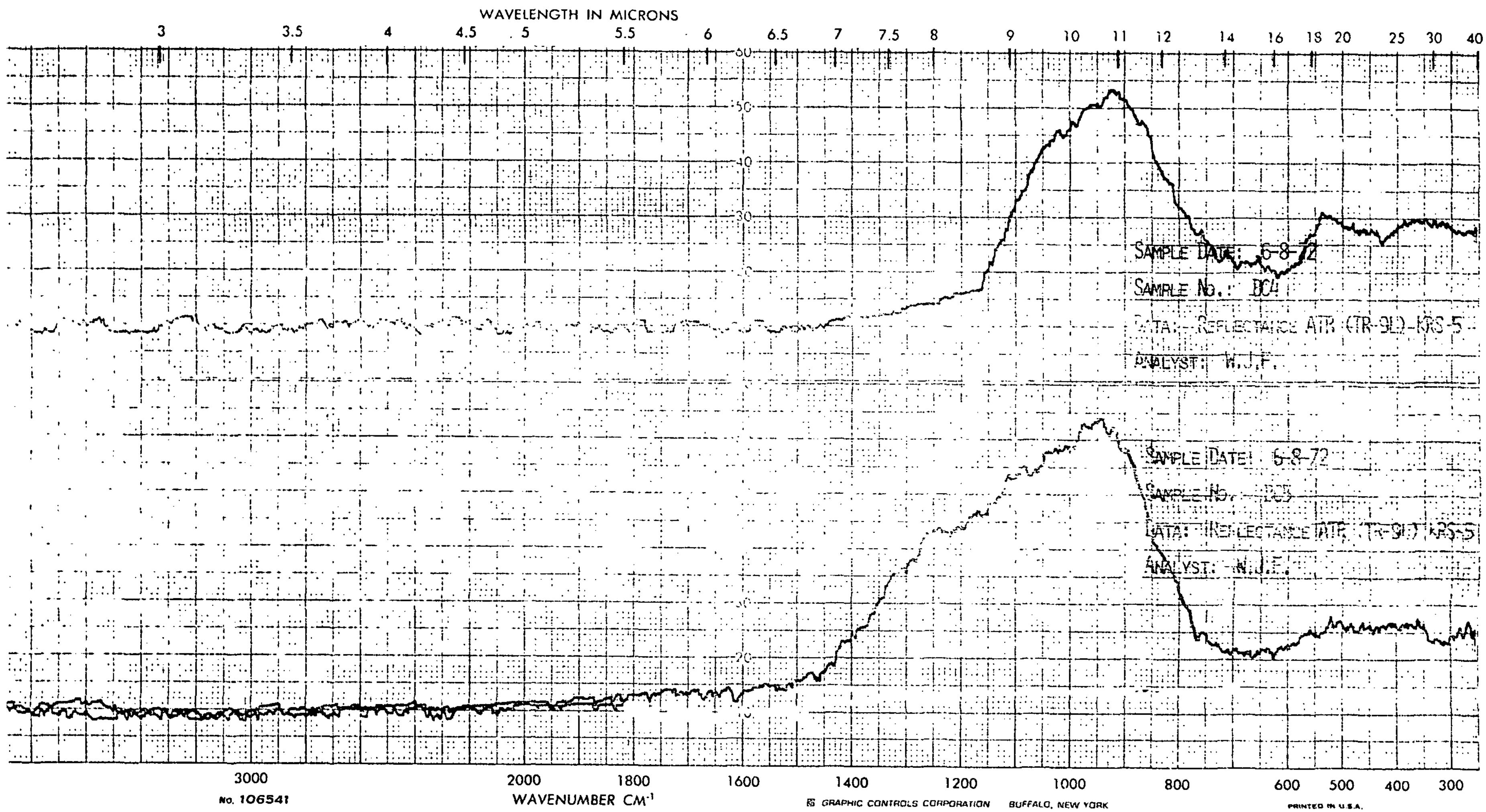
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE No.: DC4
DATA: REFLECTANCE ATR (TR-9L)-KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
No. 106541
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Figure D-2

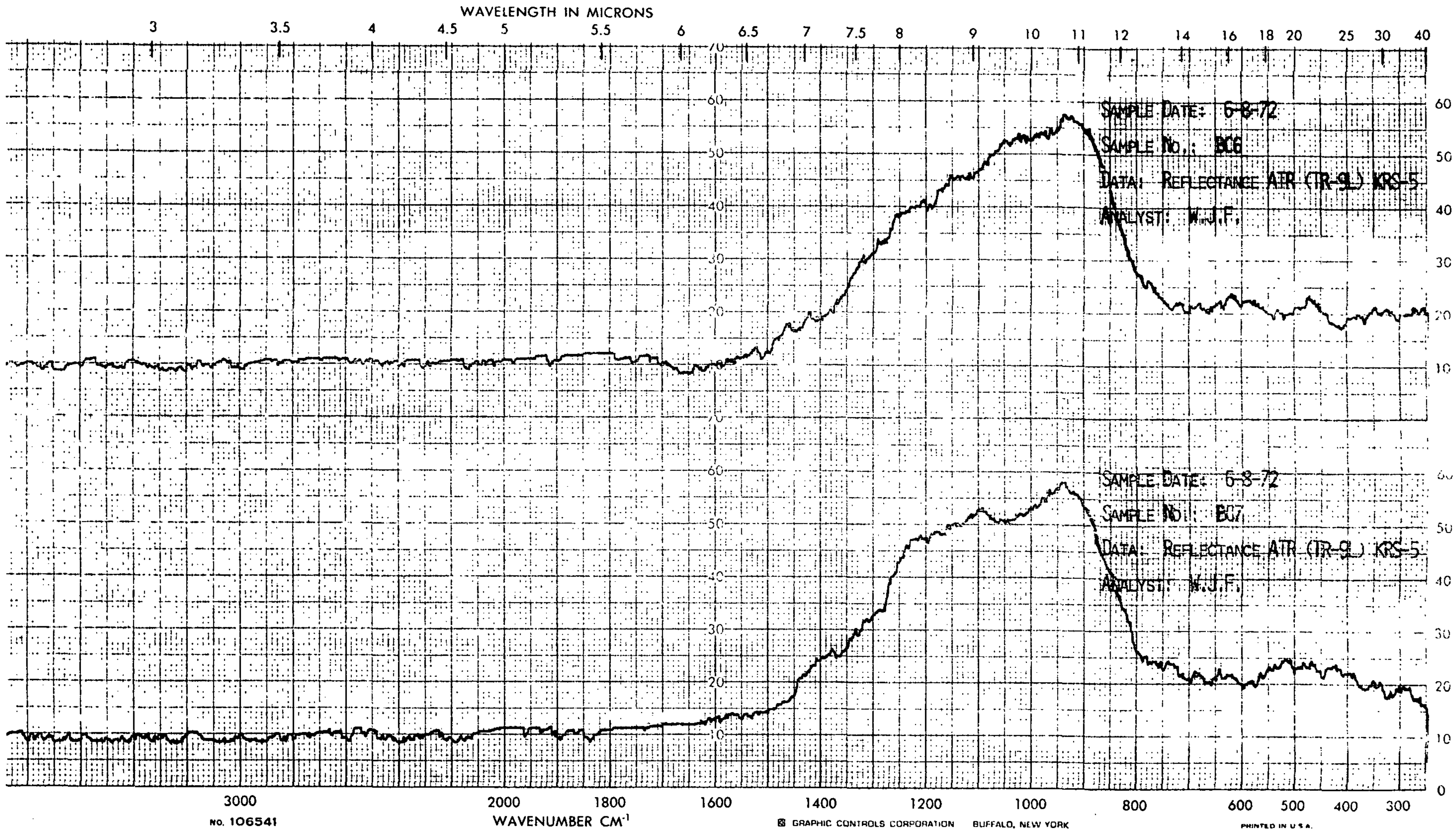
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC6
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC7
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
NO. 106541
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Figure D-3

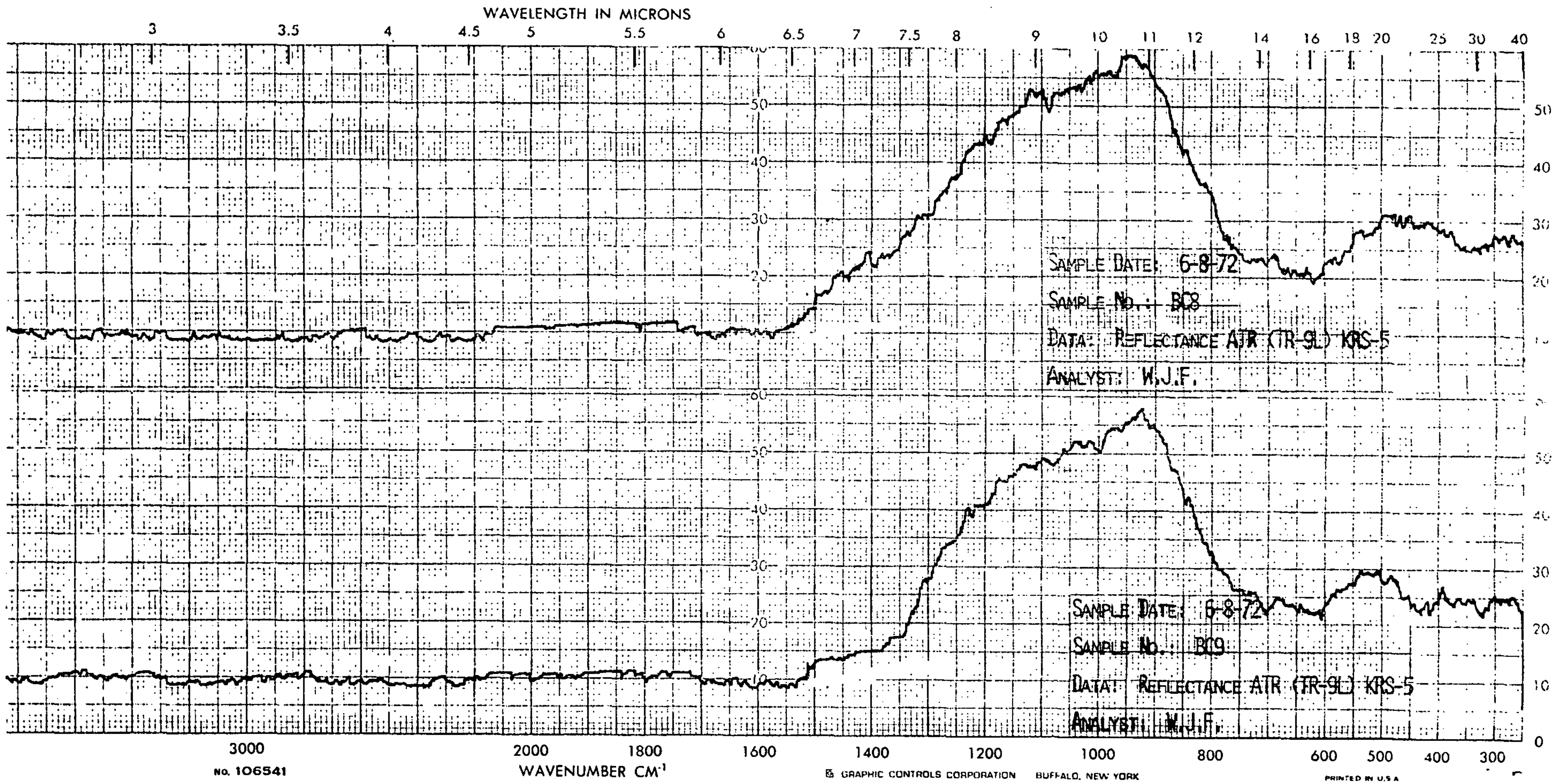
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC8
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC9
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
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Figure D-4

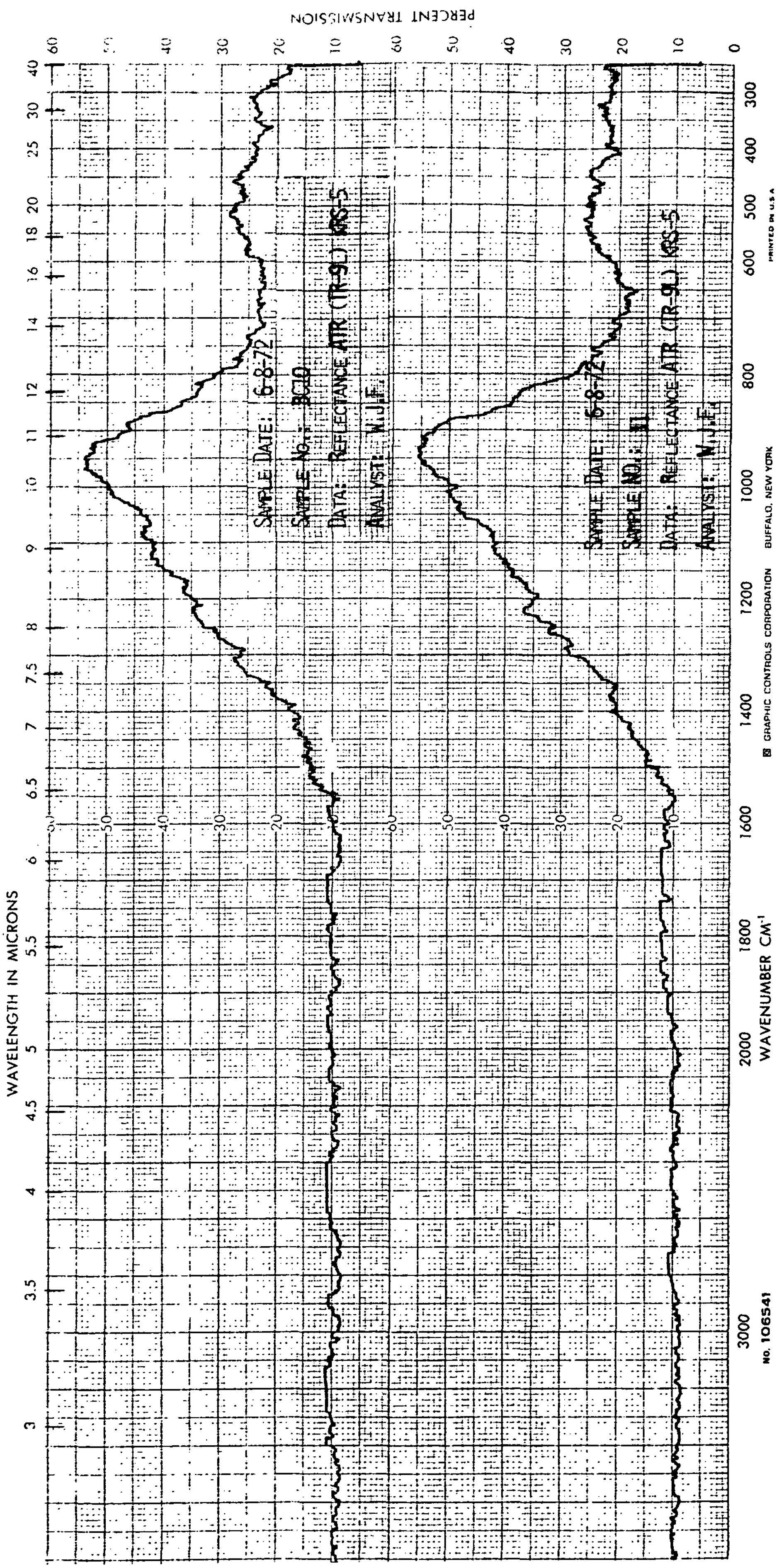
PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM-1
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC10
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: B1
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
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Figure D-5

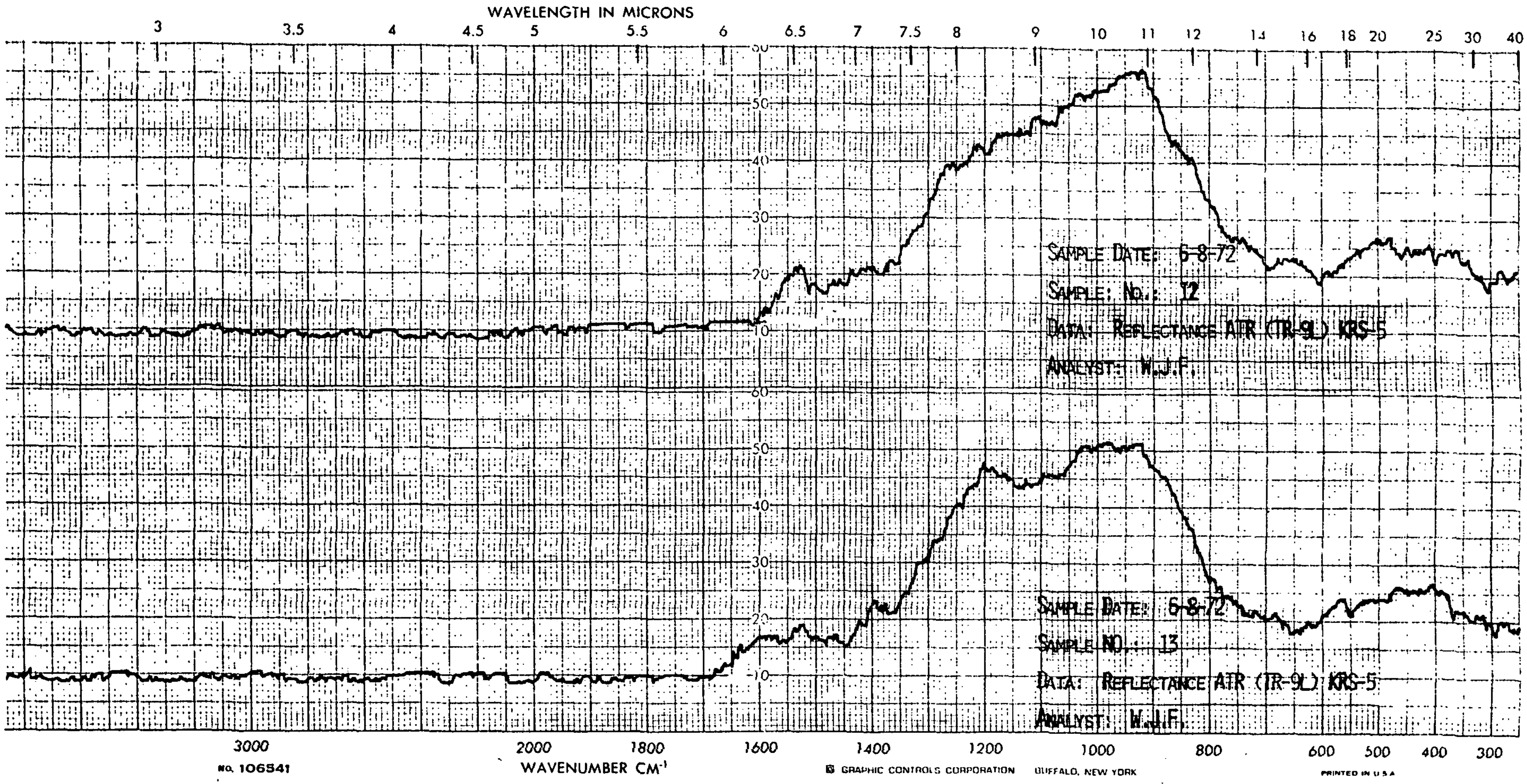
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE: NO.: 12
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 13
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
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Figure D-6

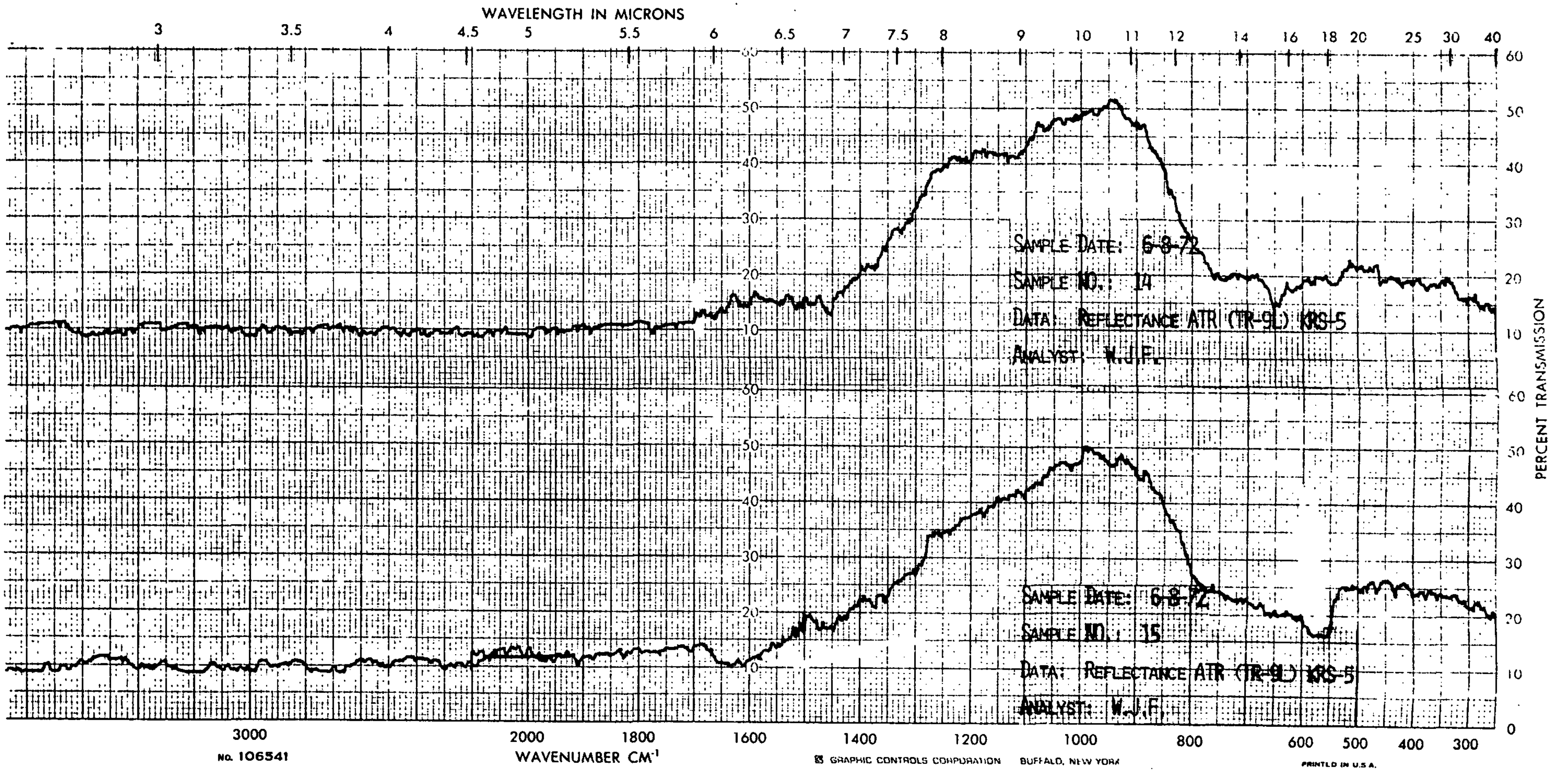
WAVELENGTH IN MICRONS
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: 14
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 15
DATA: REFLECTANCE ATR (TR-9L) KRS-5
ANALYST: W.J.F.
No. 106541
WAVENUMBER CM⁻¹
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Figure D-7

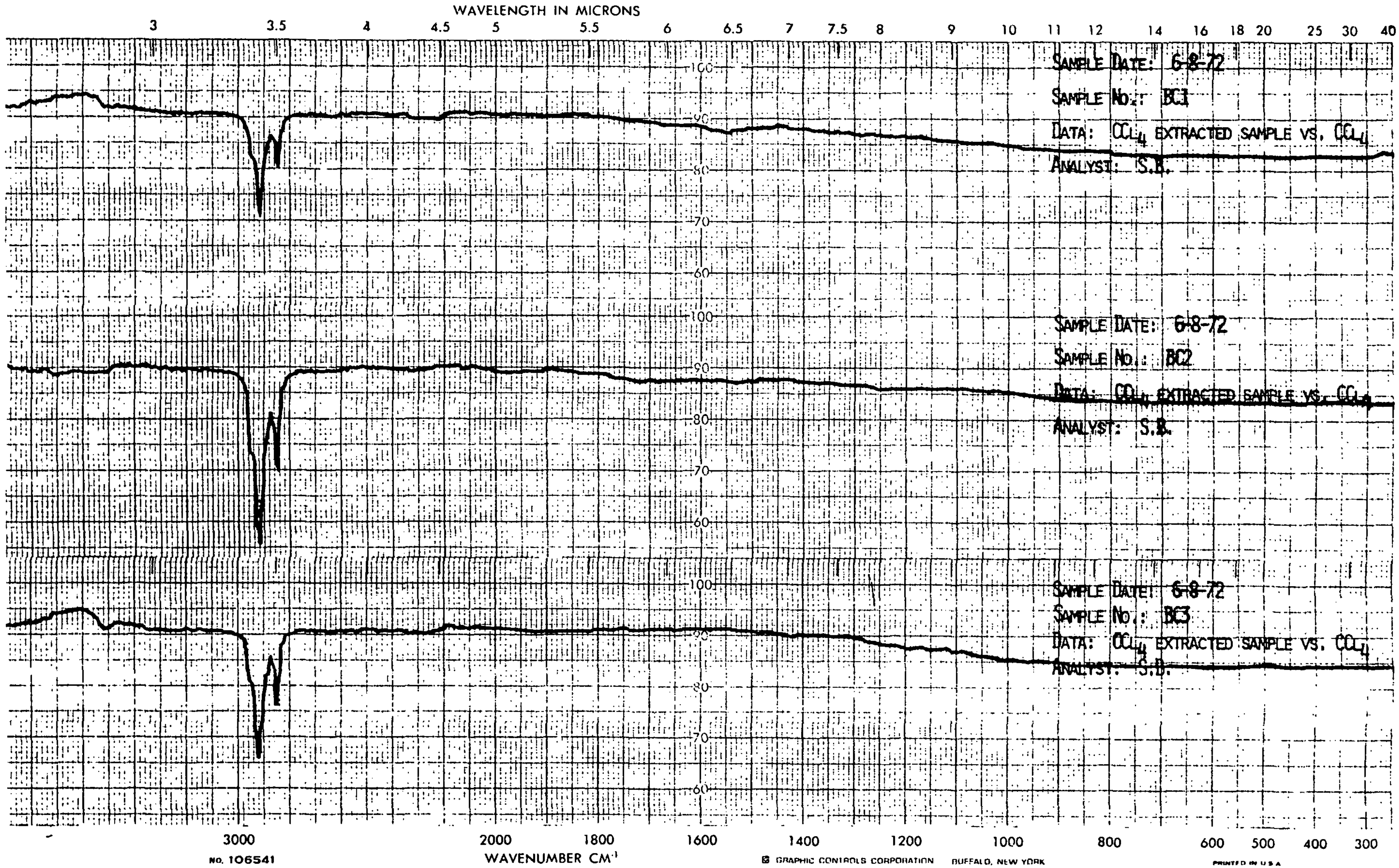
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 6-8-72
SAMPLE No.: BC1
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE No.: BC2
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE No.: BC3
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
PERCENT TRANSMISSION
100 90 80 70 60
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM^{-1}
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure D-8

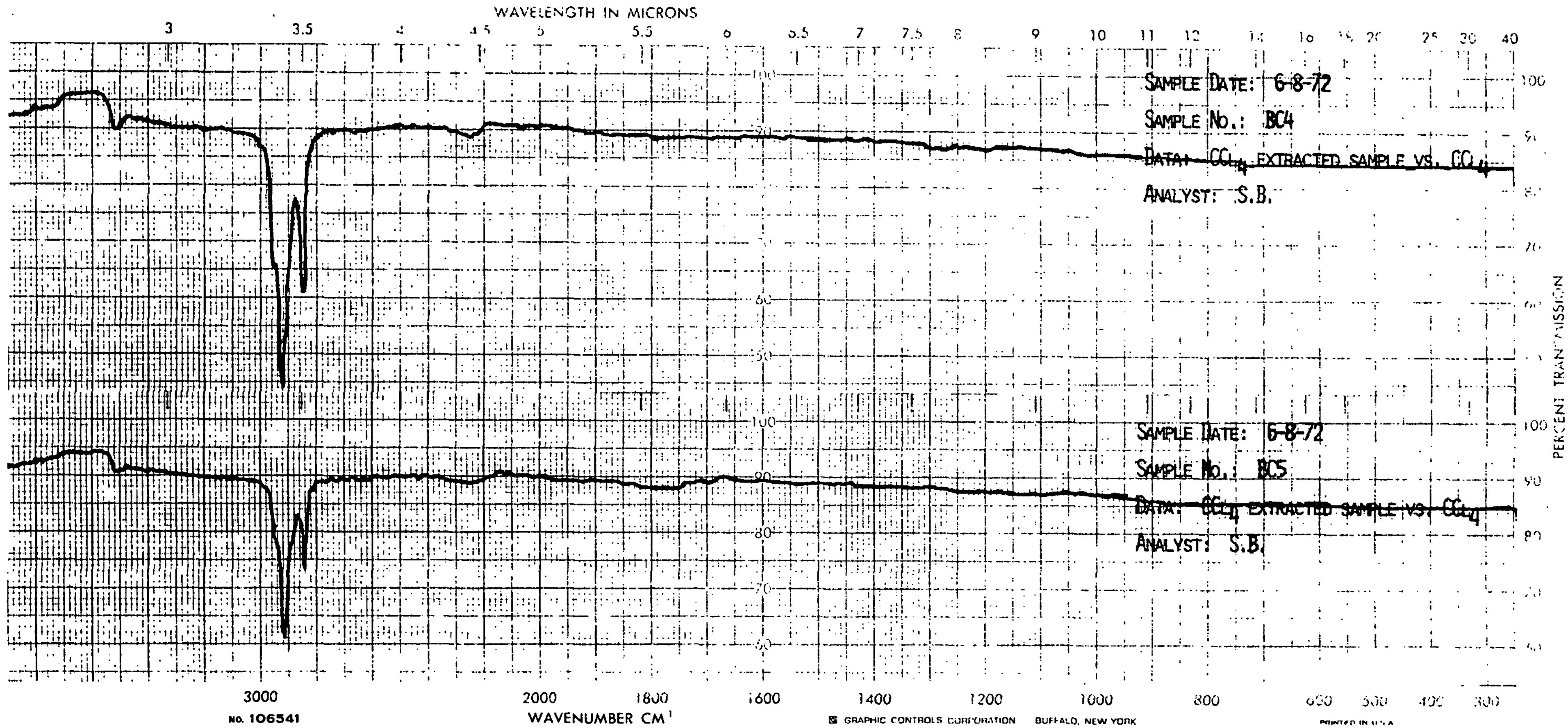
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
20
25
30
40
SAMPLE DATE: 6-8-72
SAMPLE No.: BC4
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE No.: BC5
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
PERCENT TRANSMISSION
100
90
80
70
60
50
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
No. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure D-9.

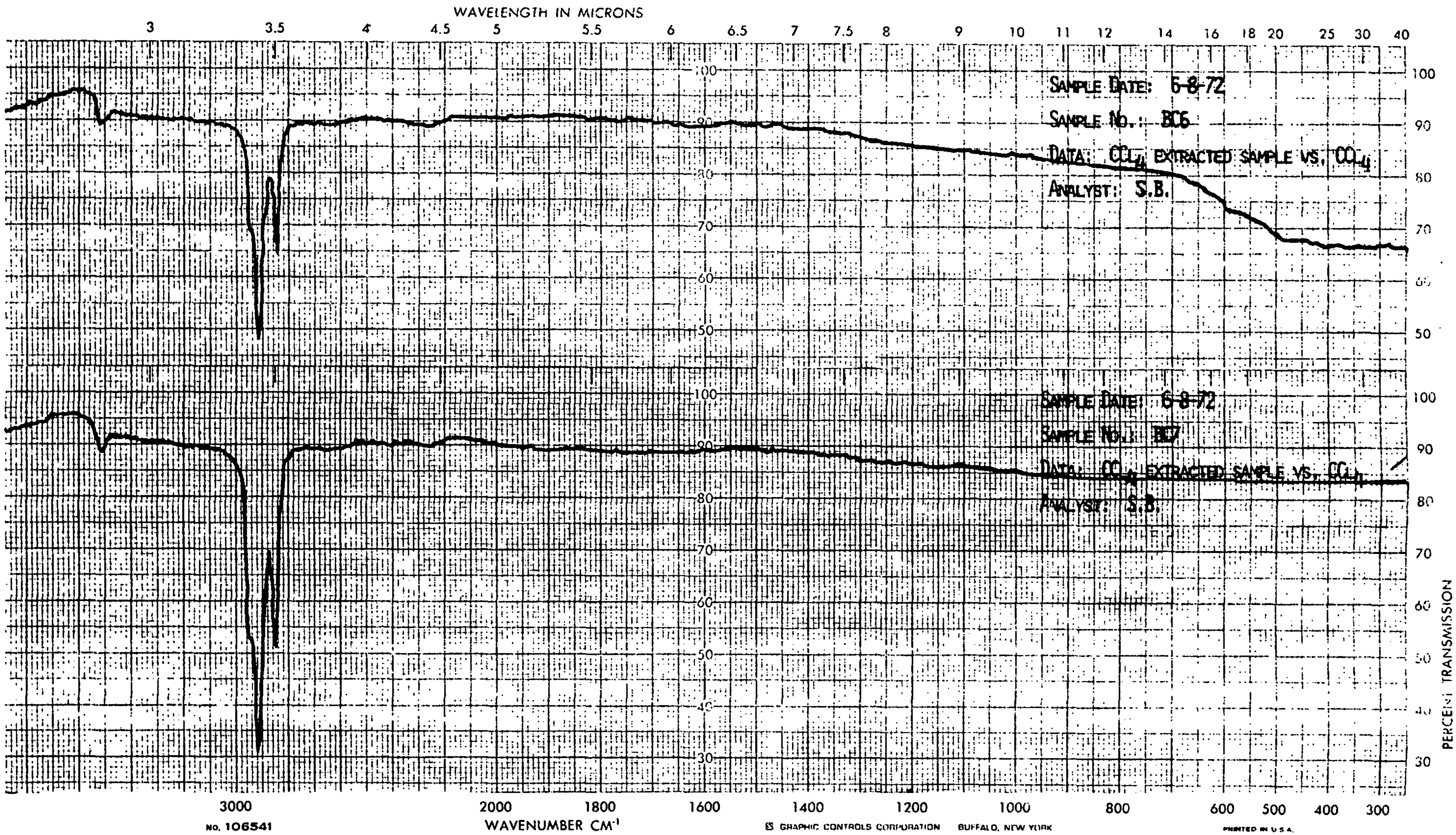
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC6
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC7
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
PERCENT TRANSMISSION
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
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Figure D-10

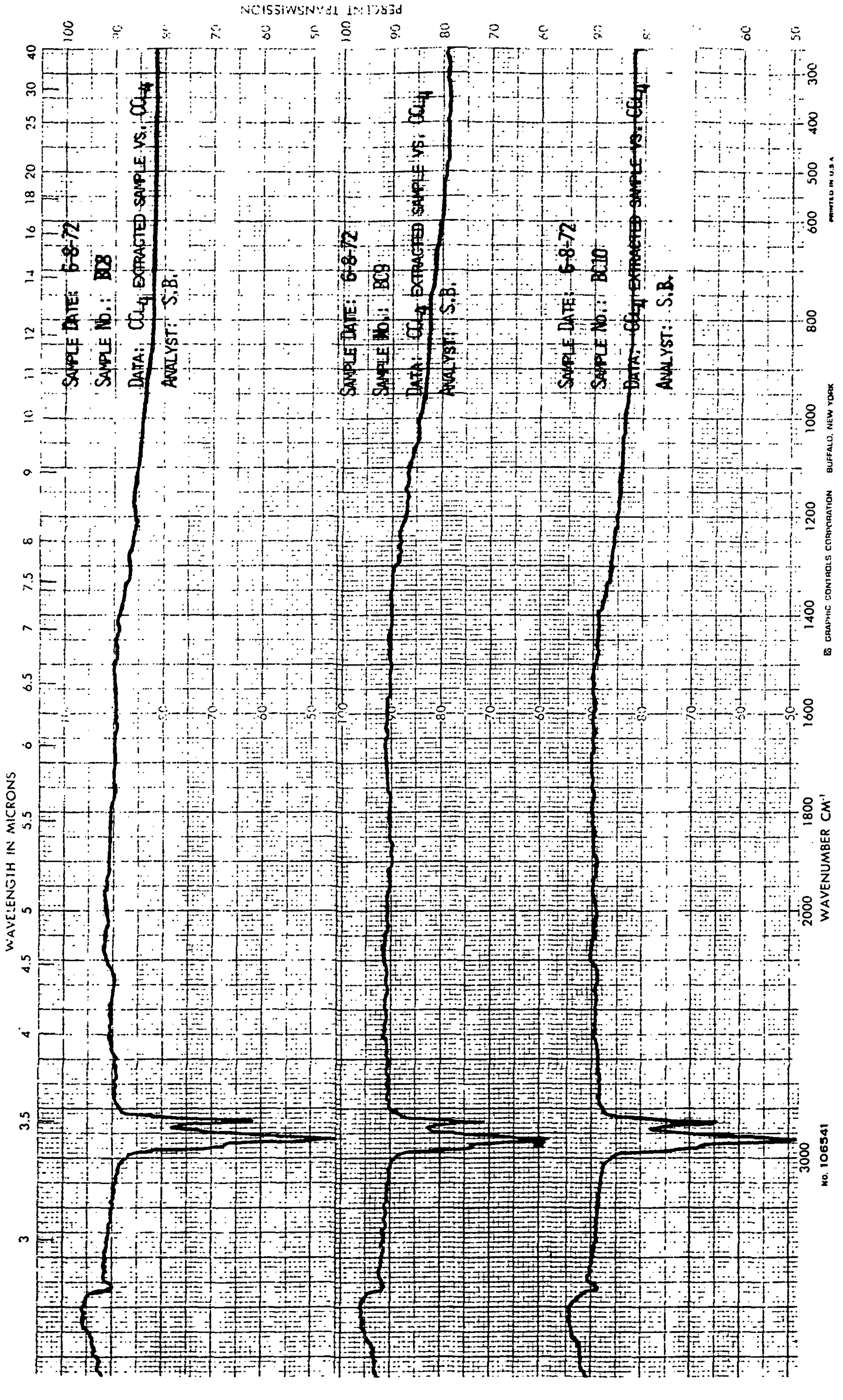
WAVELENGTH IN MICRONS
PERCENT TRANSMISSION
WAVENUMBER CM⁻¹
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC8
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC9
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC10
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
NO. 106541
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Figure D-11

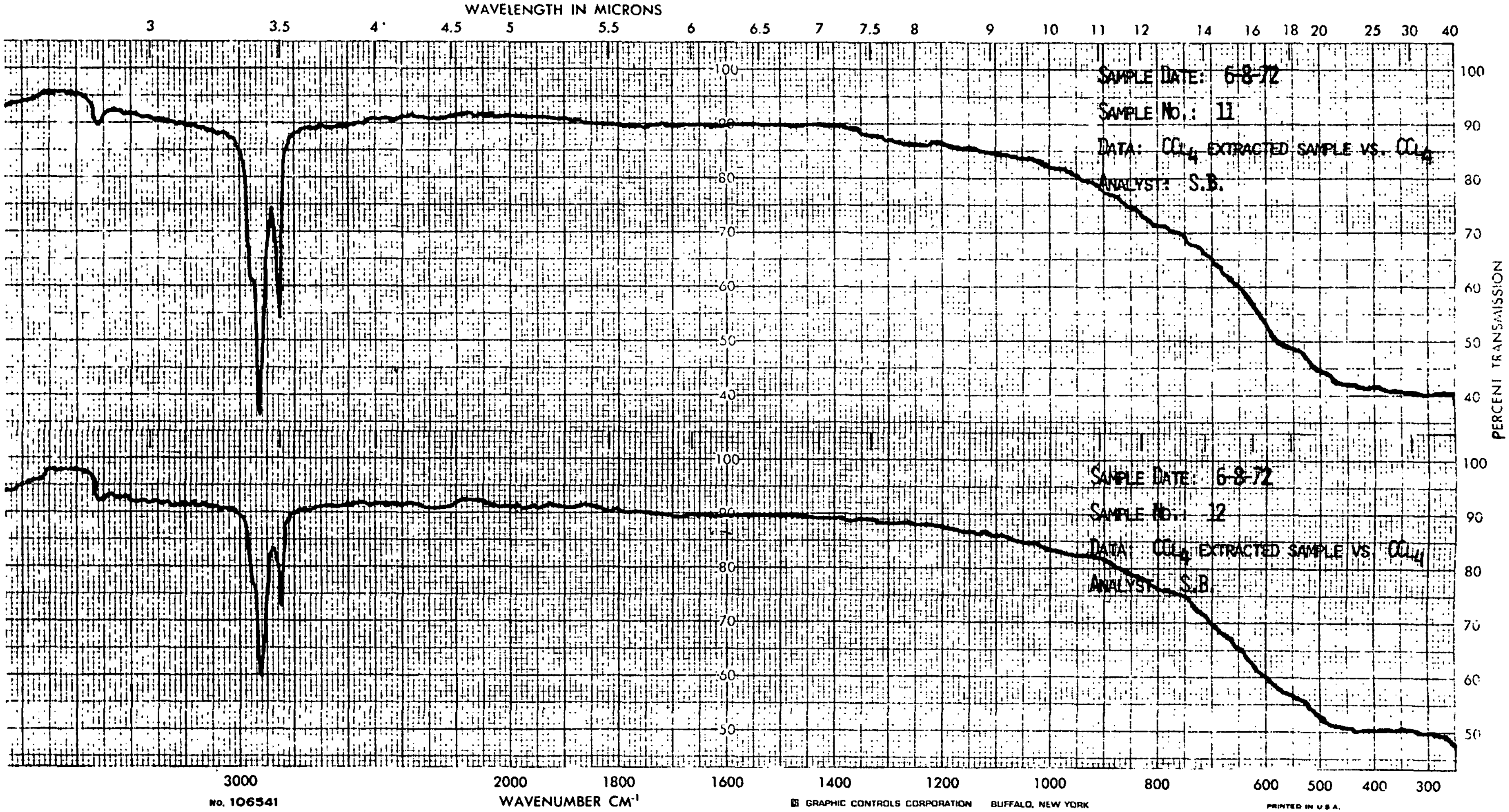
WAVELENGTH IN MICRONS
SAMPLE DATE: 6-8-72
SAMPLE NO.: 11
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 12
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: S.B.
PERCENT TRANSMISSION
WAVENUMBER CM^{-1}
NO. 106541
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Figure D-12

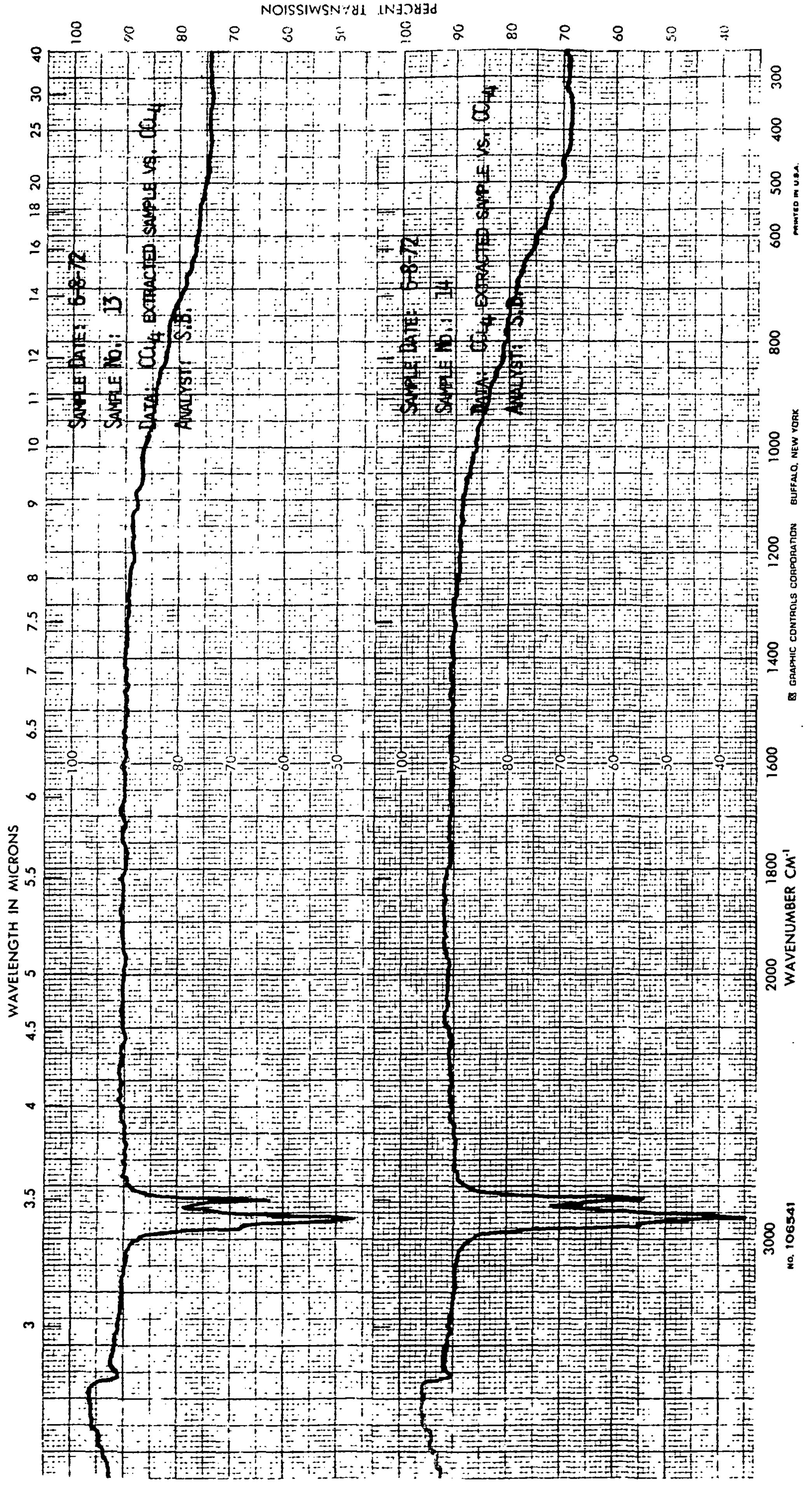
PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM-1
SAMPLE DATE: 6-8-72
SAMPLE NO.: 13
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 14
DATA: CCl4 EXTRACTED SAMPLE VS. CCl4
ANALYST: S.B.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541
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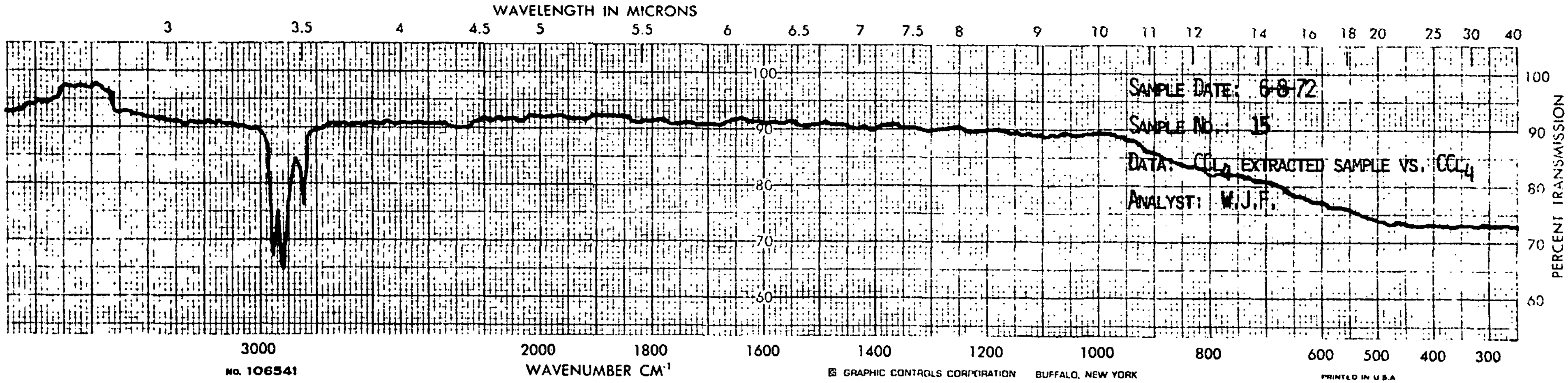
Figure D-13



WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
11
12
14
16
18
20
25
30
40
100
90
80
70
60
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: 15
DATA: CCl_4 EXTRACTED SAMPLE VS. CCl_4
ANALYST: W.J.F.
3000
2000
1800
1600
1400
1200
1000
800
600
500
400
300
NO. 106541
WAVENUMBER CM^{-1}
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure D-14

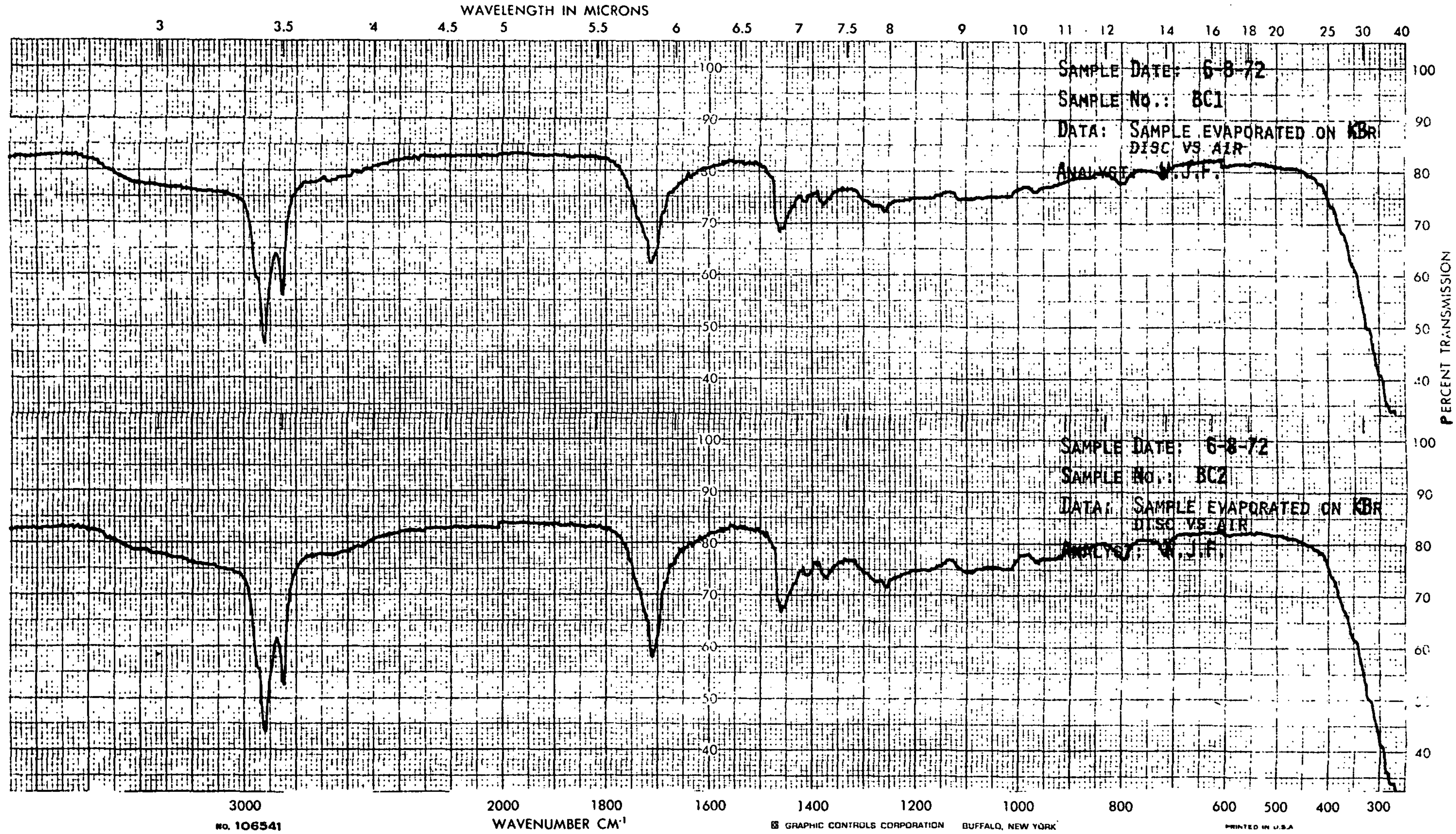
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC1
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC2
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
100 90 80 70 60 50 40
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM-1
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure D-15

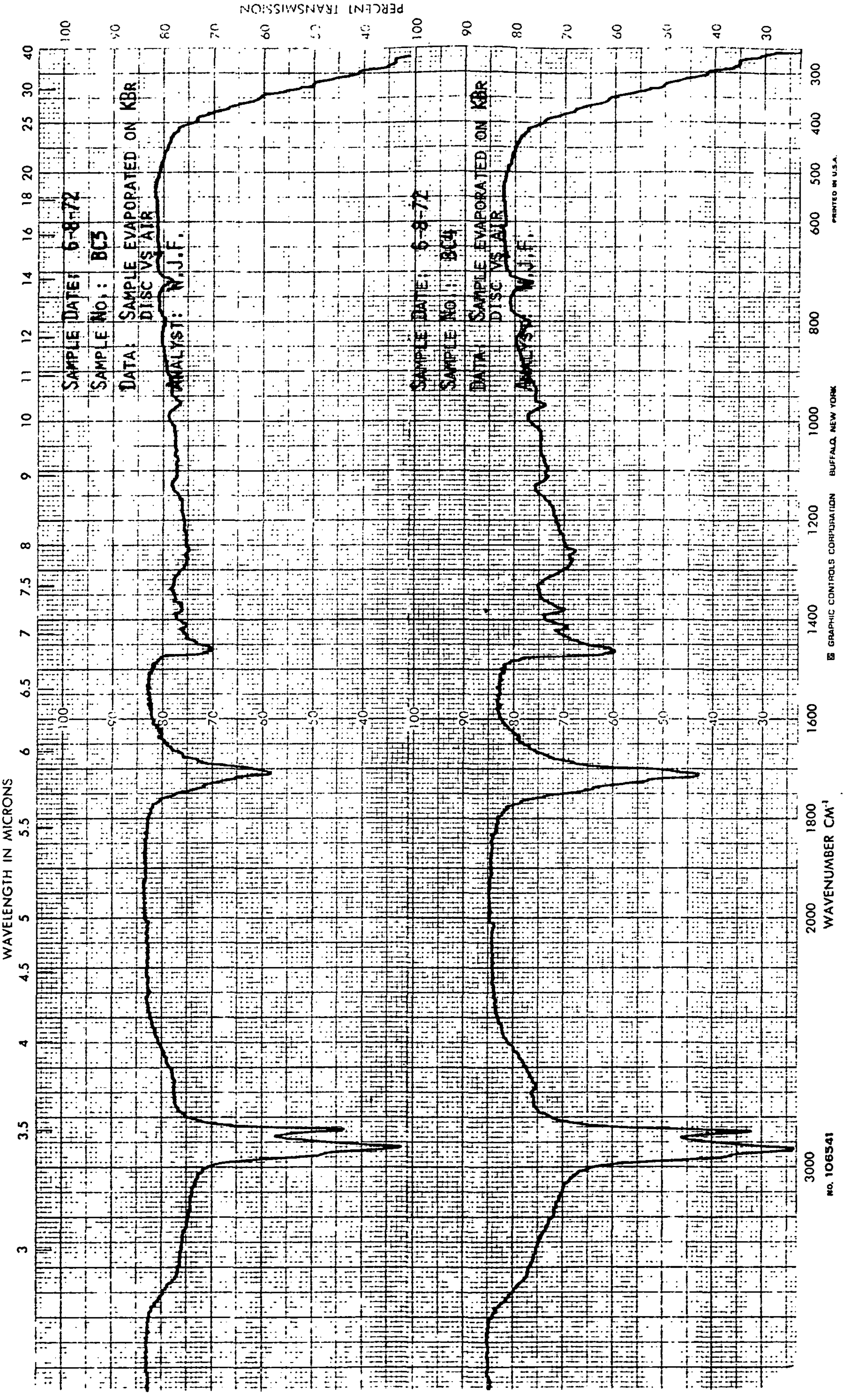
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC3
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC4
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541
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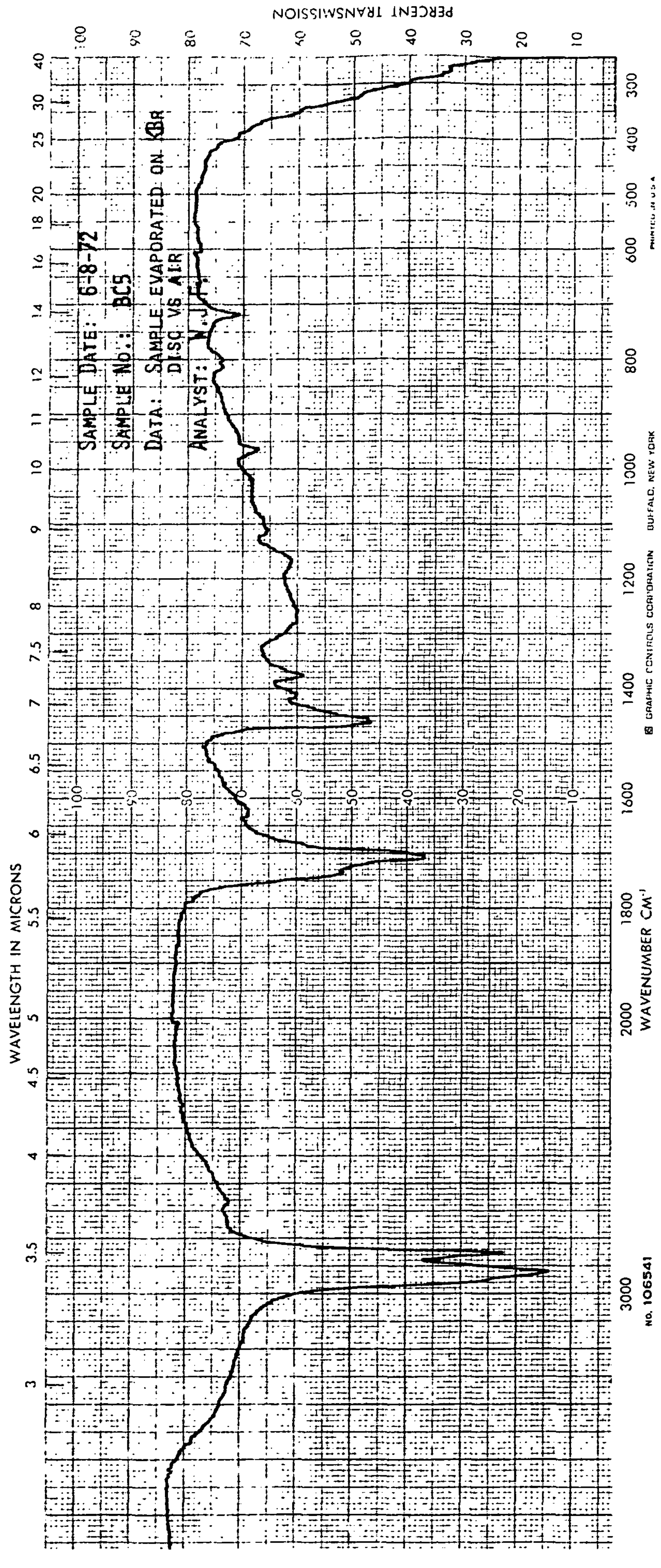
Figure D-16



PERCENT TRANSMISSION
WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC5
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541

Figure D-17

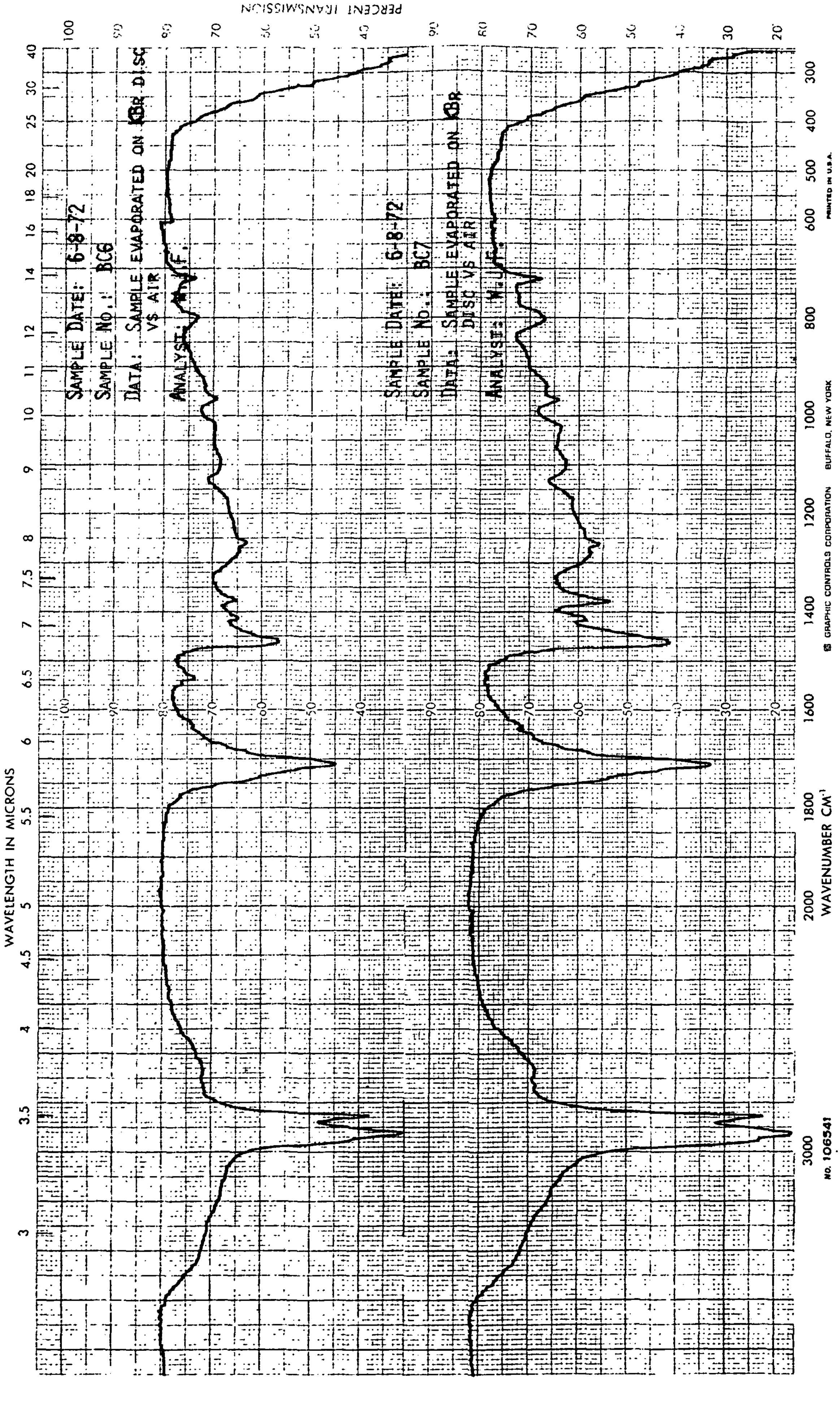

WAVELENGTH IN MICRONS
WAVENUMBER CM⁻¹
PERCENT TRANSMISSION
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC6
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: M.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC7
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: M.J.F.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
NO. 106541
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Figure D-18

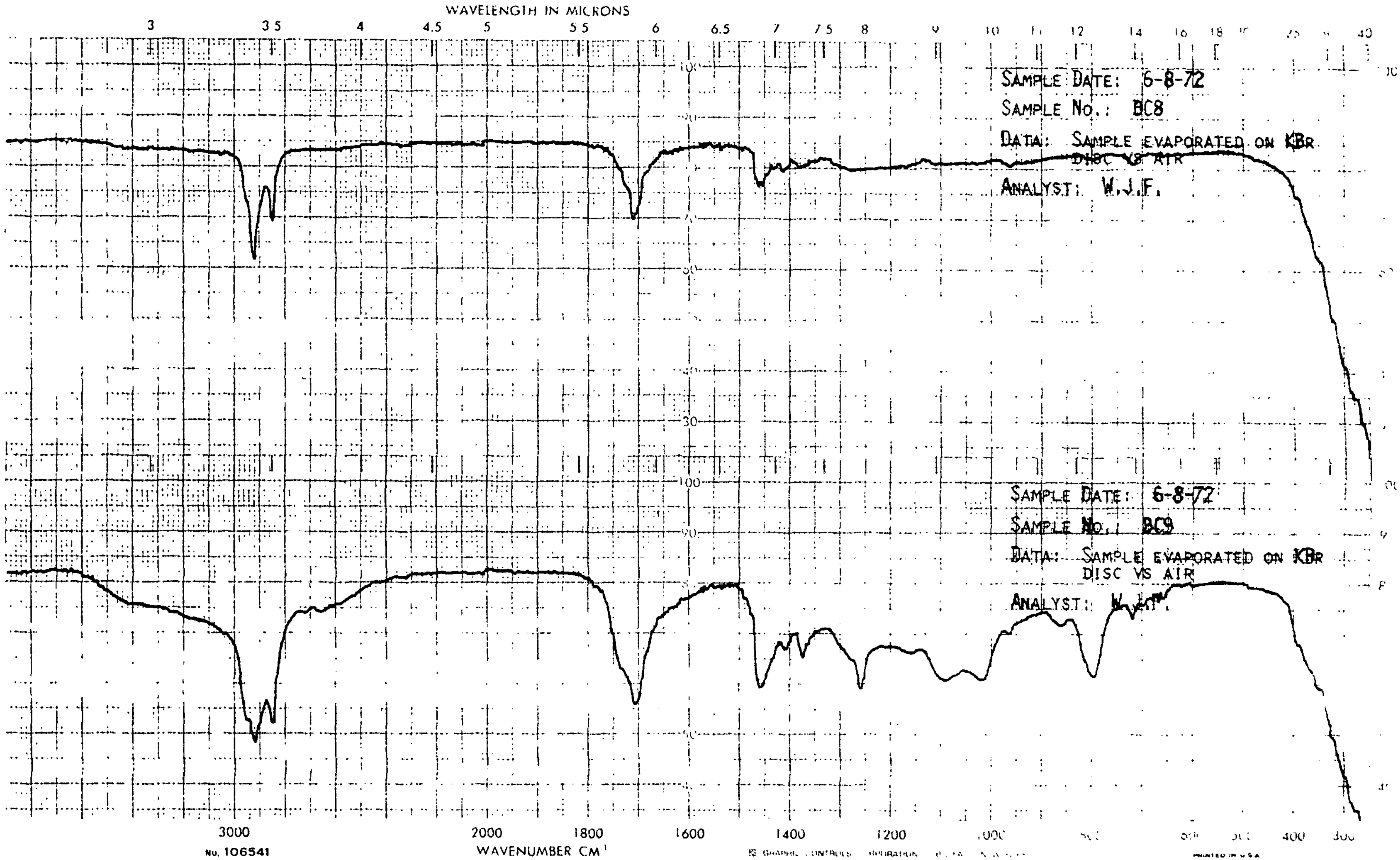
WAVELENGTH IN MICRONS
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
9
10
12
14
16
18
40
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC8
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC9
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST:
100
30
100
PERCENT TRANSMISSION
3000
2000
1800
1600
1400
1200
1000
400
300
NO. 106541
WAVENUMBER CM⁻¹
PRINTED IN U.S.A.

Figure D-19

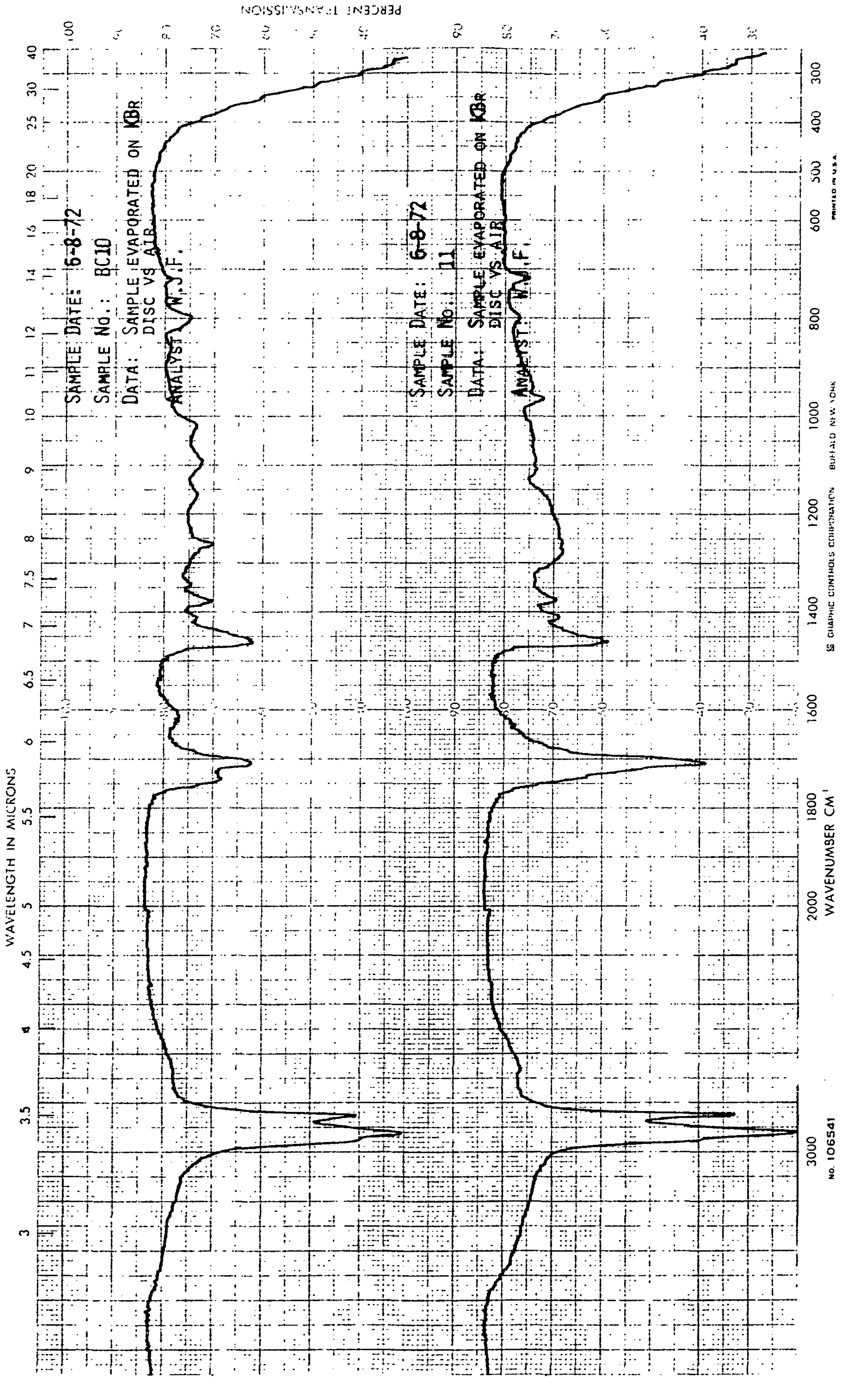
SAMPLE DATE: 6-8-72
SAMPLE NO.: BC10
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 11
DATA: SAMPLE EVAPORATED ON KBr DISC VS AIR
ANALYST: W.J.F.
WAVELENGTH IN MICRONS
WAVENUMBER CM'
PERCENT TRANSMISSION
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO NEW YORK

Figure D-20

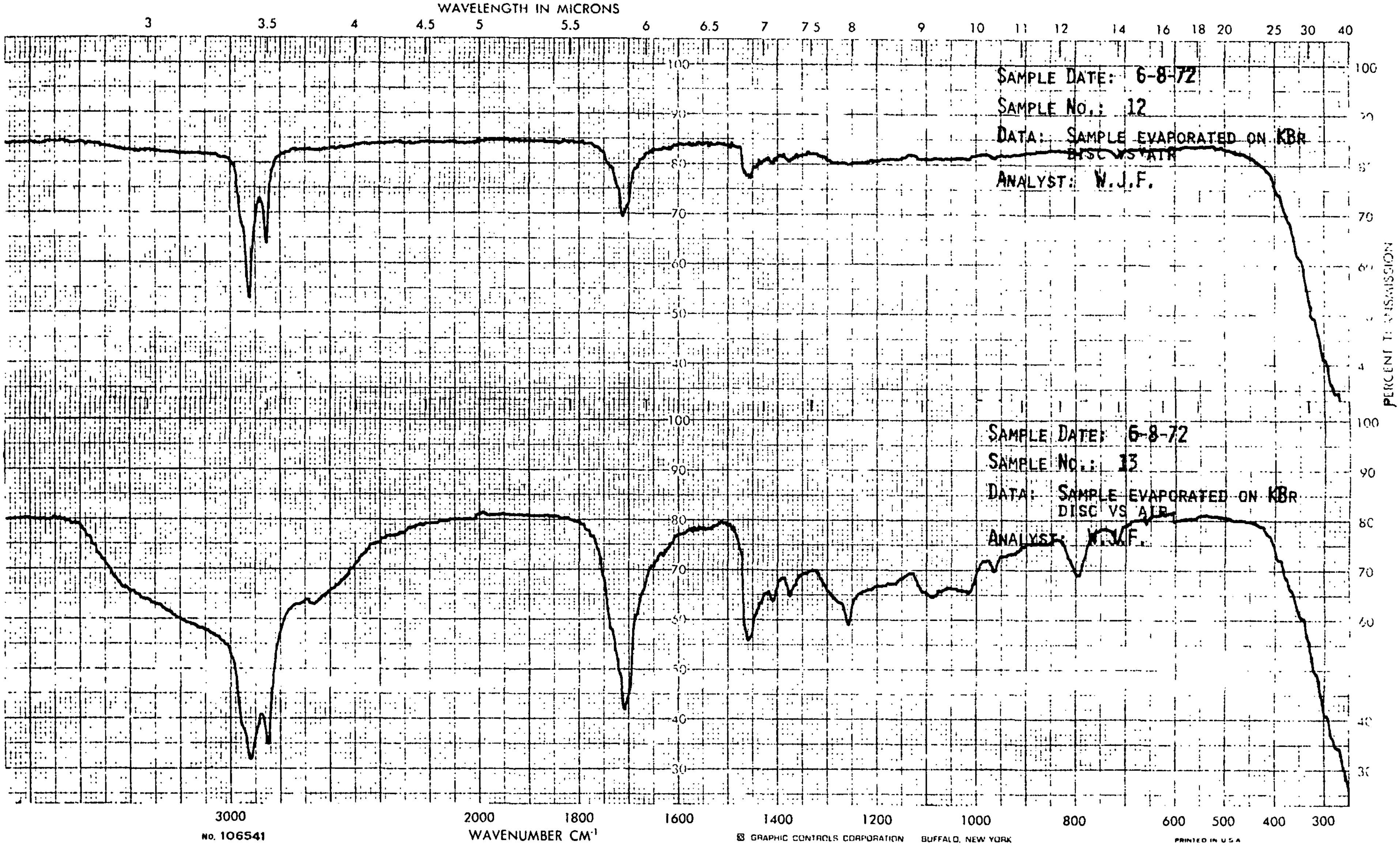
WAVELENGTH IN MICRONS
SAMPLE DATE: 6-8-72
SAMPLE NO.: 12
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 13
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: W.J.F.
PERCENT TRANSMISSION
NO. 106541
WAVENUMBER CM⁻¹
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
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Figure D-21

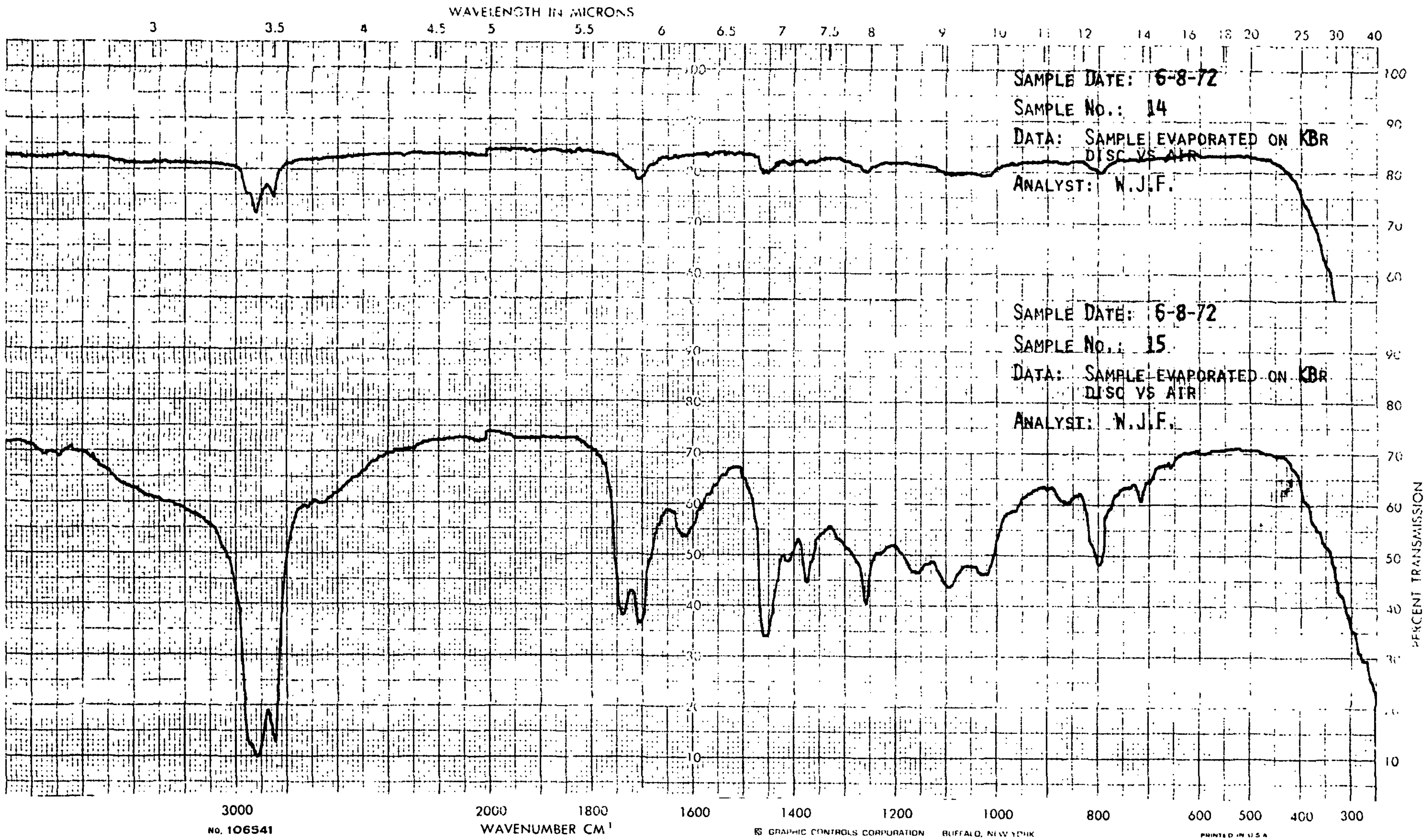
WAVELENGTH IN MICRONS
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 9 10 11 12 14 16 18 20 25 30 40
SAMPLE DATE: 6-8-72
SAMPLE NO.: 14
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: N.J.F.
SAMPLE DATE: 6-8-72
SAMPLE NO.: 15
DATA: SAMPLE EVAPORATED ON KBR DISC VS AIR
ANALYST: N.J.F.
PERCENT TRANSMISSION
3000 2000 1800 1600 1400 1200 1000 800 600 500 400 300
WAVENUMBER CM⁻¹
NO. 106541
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U.S.A.

Figure D-22

APPENDIX E

ANNOTATED BIBLIOGRAPHY

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-- Reports on the usefulness of color infrared and thermal imagery in delineating estuarine water conditions. Ref: Summaries, p. 197, 7th International Symposium on Remote Sensing of Environment, May 17-21, 1971. Center For Remote Sensing Information and Analysis. Willow Run Laboratories, Ann Arbor, Michigan.

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